



A N  
ANATOMICAL and MECHANICAL  
E S S A Y

On the WHOLE

Animal OEconomy;

In one V I E W.







BOOKS Printed for W. Meadows, at the Angel  
in Cornhill.

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80e  
A N

# ANATOMICAL and MECHANICAL ESSAY

On the W H O L E

## Animal OEconomy;

In one V I E W.

W H E R E I N

Is shewn the most wonderfull Conduct of N A-  
TURE in all the *Phænomena* attending HUMAN  
BODIES, with many curious Subjects not commonly  
treated of.

N E C E S S A R Y

For all Lovers of Knowledge, particularly Young  
Students in *Anatomy*, *Physick* and *Surgery*.

W I T H

An Alphabetical Catalogue of A U T H O R S Names referred  
to on several Occasions in the following T R E A T I S E.

By JOHN COOK, Student in *Physick*, and late of  
the College in *Edenburgh*.

---

Τὰ ἀπαντα συμπνῆν καὶ συνεῶν. Hippoc.

---

Ad causam ipsam, & causæ occasionem & primordia deveniendum est.  
*Hippoc. De Virg. Morb.*

Qui parum docti, satis seduli, multos ægros officiosissime occidunt.  
*Hippoc. L. 2. Epict. Sect. 4.*

---

L O N D O N:

Printed for W. MEADOWS at the *Angel* in *Cornhill*.  
M D C C X X X.

23





TO THE  
Most Learned and Celebrated  
THE  
PRESIDENT,  
*Electors and Censors,*  
And the Rest of the  
LEARNED MEMBERS  
OF THE  
Royal-College of PHYSICIANS  
AT  
EDENBURGH.

*This* ESSAY,

*Is humbly Dedicated*

Leigh, in Essex,  
March, 20. 17<sup>22</sup><sub>18</sub>.

By JOHN COOK.

TO THE

Most Excellent and Gracious

King

His Majesty's Council

Presented

For Consideration

By the

Commons

of Great Britain

In Parliament assembled

That

Whereas

By the

Statute

in that behalf

made

in the

fourth

year

of the

said

King

and

Queen

the

said

Statute

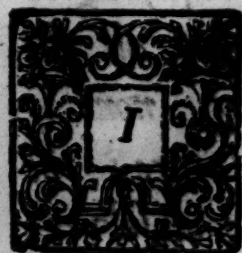
being



By JOHN COOK



THE  
PREFACE  
TO THE  
READER.



Have here put into your Hands, what hath been the Diversion of some of my leisure Hours, if perhaps they may have the good luck to prove so of any of yours. Herein I endeavour, to set in a clear Light, some of the hidden Secrets of Anatomy; and to sum up, in a few Sheets, what others have

A 4 made



*made numerous Volumes of. If you find but little in it New, or Instructive to your self, blame me not, for it was not designed for such as were Masters of this Subject already, but for my own Information, and the Satisfaction of a few Companions I had, when attending St. Thomas's Hospital, to whom this was then promised; and had much sooner been performed, had not the sudden Death of my Father disappointed me.*

*And here, I need not recommend to you, the Noble Study of Anatomy, by telling of you, the many and great Advantages, that naturally accrue from the right Knowledge of it; for I believe you will easily agree with me in thinking, that among all the Advantages in human Learning, none is greater than to have Skill in Nature; the highest Pitch of which is, to know ourselves; even in a natural Sense, respecting the Structure and Composition of our Bodies; which is a Study fit, not only for Philosophers, but Physicians also; and all curious Men. To say no more; the Honour,  
Plea-*

*Pleasure, as well as Profit, that results from this Knowledge, are sufficient Motives, to excite our endeavours towards it, and to be a full Encouragement of it, both in ourselves and others. And the many late, and new Discoveries, constantly supply us with fresh and strong Hopes of a most successful Progress therein: Wherefore we may truly say, that Anatomy never flourished more, nor yet so much, as in this our noted Age.*

*For which Improvements, we are ever obliged to the invincible Industry of the noted Assellius, for the discovery of the Lacteals; and to Pacquet, for the Receptacle of the Chyle: To the Noble and ever renowned Harvey, for the Circulation of the Blood: To the sagacious Willis and Ridley, for the Brain and Nerves: To the Judicious Keil, for the Glands: To the Famous Glisson, for the Liver; with many others. As the Acute Malpighius, on the Glands of the Brain: The Great Lower, on the Heart: The Industrious Regnar de Graef, on the Genitals: The Ingenious Havers and Monro, on the Bones: And the Curious  
Douglass*

Douglafs and Cowper, on the Muscles. These I say, with several others, both at home and abroad, have much adorned the Noble Study of Anatomy: And, by their Labour and Industry, have rendered it more evident and easy to us.

Since it is so then, it may possibly be censured as a great Piece of Vanity, and even Insolence in me, to pretend to instruct this our knowing Age. I answer, as before, that this ~~was not~~ designed for the more Learned, but for such as stand in need of plain Instructions; and though we cannot be a Boyle or a Newton; nor have the good luck to be a Sydenham or a Harvey, yet we may be under-Labourers, to clear the Ground a little, and remove some Impediments, that still lie in the way of Knowledge; and therefore this is all my Apology, that at the Request of my Fellow Pupils, I writ this Treatise, avoiding therein, as much as possible, the Imputation of a Plagiary, by mentioning those Authors, which I have an occasion at any time to make use of, and learned any thing  
from



# P R E F A C E.

V

from; the necessity of a free Discourse, requiring, sometimes, the Assistance of other Mens Labours; though many things herein will be New; and the Manner and Method of explaining the others, entirely my own; which I shall do in the following Order; not pretending positively to be in the right in every Particular, well knowing, humanum est errare, nothing being easier to frail Man than to mistake; and if I have erred in any Point, or do not think the same with your self, it is no more than my Betters have done before me. And as by writing this, I do not pretend to be wiser than others, yet herein I endeavour to be more Laborious than some, who are much more able for such Undertakings, and can only say, with that Reverend old Gentleman, Ego vero cupio te, omnia quæ scio, transfundere; & in hoc gaudeo, aliquid discere, ut doceam. Senec. ad Lucel. Ep. 6. Wherefore then, if any shall reap Pleasure in the Perusal of the following Sheets, I am well pleased; and if any are disturbed at it, I answer, irridere quam imitari facilius est,

est, and conclude, that if this shall either assist the Memory of those that are well versed in such Studies, or any ways instruct young Beginners, I have wholly obtained my sole End and Desire.





A  
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OF THE  
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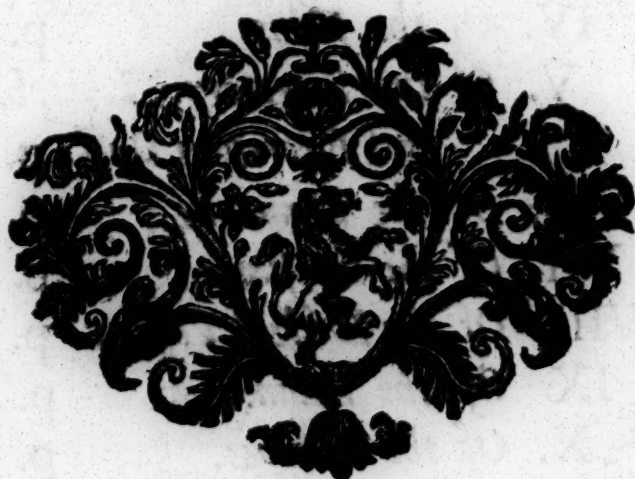
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*The NAMES of the AUTHORS  
referred to on several Occa-  
sions, in the following TREA-  
TISE.*

**A** Scellius.  
Baglivi.  
Bartholin.  
Bauschius.  
Bellinus.  
Boulton.  
Boyle.  
Borellus.  
Boerhaave.  
Charlton.  
Cheyne.  
Cowper.  
Diemerbroeck.  
Des Cartes.  
De Graef.  
Drake.  
Etmuller.  
Fernellius.  
Fuller.  
Galen.  
Gibson.  
Glisson.  
Grew.  
Gravesend.  
Harvey.  
Hale.  
Havers.  
Handley.  
Helmont.

Hippocrates.  
Highmore.  
Hook.  
Jones.  
Keil.  
Lewenhoeck.  
Malpighius.  
Mead.  
Monro.  
Newton.  
Neuwentyt.  
Pacquet.  
Pemberton.  
Philos. Transact.  
Pitcairn.  
Quincy.  
Ray.  
Rohault.  
Roberfon.  
Ruyfch.  
Sanctorius.  
Sennertus.  
Sydenham.  
Turner.  
Verheyen.  
Verduft.  
Wainwright.  
Willis.  
Worster.

**BOOKS**

## ERRATA.

**P**AGE 8. Line 10. For, the Solar. Read the Solar.  
p. 44. l. 22. for, is r. are. p. 69. l. 3. for, there  
r. there. p. 98. l. 5. dele which. p. 123. l. 10. for, As  
r. And. p. 193. l. 11. for, Glands r. Fluid. p. 216. l. 1.  
for, every r. very.

If there are any other Errors, the Author doubts  
not, but the candid Reader will excuse them, by Reason  
of his Distance from the Press.





A N  
Anatomical *and* Mechanical  
E S S A Y  
O N T H E  
Whole Animal O Economy.

---

C H A P. I.  
*Of the* S O L I D S.

I N T R O D U C T I O N.



A N, the everlasting Monument  
of his Master's Majesty, is a  
most noble Machine, of most  
excellent and wonderful Com-  
position, whose corporeal Parts  
are an elegant Combination of infinite  
Numbers of Atoms, of Matter of various  
B Figures

The Com-  
position of  
an Animal  
Body.

Figures, Motions and Magnitudes, which are so nicely adapted to each other, as to form all and every Part of that noble Creature, in such wonderful Symetrey and Sympathy necessary for all the Functions of Life.

Of the Method made Use of in this Treatise.

Now the Anatomical Order which I shall observe in treating of each Particular, shall be as followeth : First, I shall treat of the Solids in their order, *viz.* The Heart, Arteries, Veins, Secretory Ducts, Lymphaticks and Excretory Ducts ; under which all and each of the solid Parts of the Body may be included. Then secondly, I shall examine their respective Juices, *viz.* Blood, Animal Spirits, Saliva, Lymph, Pancreatick Juice, Bile, Chyle, Milk, Menfes and Seed ; together with the excrementitious Fluids, Urine, Sweat and perspirable Matter.

Of the original, or first Stamina of Animals.

But before we enter into the Particulars of this Treatise, it will be proper to propose this one Question, as a necessary Introduction to what we are about to say ; and that is, How are Animals continued successively by Generation, or where and after what Manner have they their first Origin ? This hath employed the Industry of many learned Men, and at last they differ in Opinion concerning it ; both as to the Time when, the Sex from whom, and the Manner how. Though I can here promise

## INTRODUCTION.

3

no Certainty in this Enquiry, yet for the sake of the Curious, I shall examine a little into the several Opinions of Authors about this Matter, and then leave the Reader to chuse which he likes best.

As to the first, some would have the Stamina of each particular Animal to be as old as *Adam*, whilst others again are for confining it to the immediate Parents: And as to the Sexes some would have the whole Animal proceed from the Male, and others from the Female, and some again would have it from neither simply but from both, by a joyn't Mixture of their respective generative Juices: And as to the Manner how the Animal acquires its Form, some will have it to be delineated in the Ovum of the Female upon Conception, by the prolifick Spirit of the Male Seed, whilst others again would resolve it into the immediate *Fiat* of the wise Creator when he made Man at first. From all these Hypothesis, I shall now endeavour to chuse the most Rational one, and expose the Weakness of the others; and here I must beg the Reader to excuse and bear with the Failings hereof, being ever ready to retract, when better informed; till then shall continue to think of the Matter as here laid down.

The several  
Opinions  
of Authors  
examined.

It is very reasonable then to think, that the Stamen of each individuate Animal did once exist in, and entirely proceeded from



that first Parent, whole and entire in its kind, as we see it after Birth ; and as to the Sex from whom it does proceed, it is also highly reasonable to believe this Animal to be solely and wholly the Product of the Male Sperm : If so then the Manner how it received its Form will be easily understood, as the Sequel of our Discourse will presently show. But before I lay down the reasonableness of this Hypothesis, it will be proper first to know the Weakness of the others, which will also afford us some clearer Light towards a right Notion of this Doctrine of Animalcula in the Male Seed.

Why the  
Stamina of  
Animals  
cannot pre-  
exist in the  
Ovaria of  
Females.

*Vid. Grew's  
Anatomy  
of Vegeta-  
bles.*

To begin with those who would have the Stamina or Animalcula to pre-exist in the Eggs of the Female, I shall offer thus much against it : First, they can prove no such Existence of a formed Animal from ocular Inspection in the Female Ova, neither do they pretend to it, as having never been able to discern the least any what like it ; and as to Reason they can prove nothing from thence, only suppose so from the Analogy which they fancy they bear to Plants. It is true, there are in the Seeds of all Vegetables, a certain Stamen or Vegetable Embryo, which is the first Rudiment or Principle of a distinct Plant, of the same kind with the Seed, with all and every part of it in Miniature ; but to apply  
this

## INTRODUCTION.

5

this to the Female Ova, is not near so reasonable, as to apply it to the Animalcula seen moving in all Male Sperm; both as we have here ocular Demonstration for it and Analogy besides; for as Plants serve within themselves the Office of both Sexes, it follows that those Stamina that are seen in them, answer to the Animalcula seen in *semine Masculino*. And as the Earth seems as a Nidus for all Seeds of Vegetables, so the Ova of the Female serve for the like Use of them of the Male; and to think otherwise would be making Woman the chief Person in the Creation, in as much as she is supposed to contain her Species, both materially and formally in her self, and needs only a little of the Spirit of the Male Sperm to set those Animalcula in Motion; so that instead of God's giving Woman for a Help-mate to Man towards Procreation, he is thus made Womans Help-mate; and so hath the least share in this Action; whereas by Nature he was designed the chief Agent in it, and that from his Loins should proceed all Mankind, and by his Name they should be called; which that Text of St. *Paul* well alludes to, when he says of *Levi*, that he was yet in the Loins of his Father, when *Melchisedeck* met him. *Heb. vii. 10.*

The Reason they give for the Animalcula being contained in the Ova originally

is, that it consists better with the wise Providence of Nature than if they were in Male Sperm ; for here are perhaps say they, about twenty Eggs in a Womans Ovary, these serve as a Repository to keep them safe till required ; whereas they must necessarily be wasted if in the Male Seed, by several ways, as fruitless Coition and the like ; or, by being continually circulated along with the other Humours of the Body, must consequently among them be voided by Evacuations : But granting all this, though I know not whether it be or no, yet there remains Animalcula enough for Generation, as we daily find, and those that are so wasted or lost are of no value, nor in the least unbecoming the wise Creator of them, forasmuch as they come not under his especial Providence till Conception, and therefore till then are no more than any other Parcels of Matter, and no more inconsistent with the wise Providence of Nature, than the great Waste of Vegetable Seeds which we daily see : But even granting them this too, still they are not without the same Difficulties in their own Hypothesis, for they cannot deny, but many of those Ova themselves come to nought, and so likewise must the Animalcula they contain. Thus we see but little can be said in Defence of this Hypothesis, and who will be farther informed about the  
the



## I N T R O D U C T I O N.

the Mode of Generation, may consult the great *Harvey* and *Leuwenhoek*.

*Vid. Harvey's De Generatione Animalium.*

Secondly, as to those that hold that the Coition of both Sexes, is necessarily required to the Formation of the Stamen, and that it did not pre-exist in either of them before Conception, I offer thus much:

The Hypothesis of Men holding the Coition of both Sexes necessary, examined.

First, that they have as little to say in defence of it as the former; and according to the Uniformity of Nature in the Production of Plants, it is reasonable that the Stamina of Animals should exist either in Male or Female before Conception, and that it does so is plain to the Learned, because it is not possible that such a fine Machine as an Animal Body, can be formed out of any part of Matter how fine soever, or however well qualified with Motion, but must of Necessity derive its Origin from God himself, and from no less Cause; and as he created all Bodies at first in the Space of six Days, so he created all the Stamina of Animals at that time too, from which

*Vid. Pitcairn, p. 164.*

time the Motion of the Heart took its Date; more of which may be seen in Dr. *Pitcairn*, where he shews that no Animal is ever produced mechanically; from whence he concludes, that the Fluid derived from the Male, brings with it an Animal into the Womb and Ovaries of the Female, which before enjoyed the Circulation of the Blood and the Benefit of Life: And as to those

## I N T R O D U C T I O N.

*Vid. Hand-  
ly's Animal  
Oeconomy*
 Scruples of Conscience which Mr. *Handly* observes, to me, they are none ; for sup-  
 posing the Stamen to be totally in the Male  
 or Female, and not produced by joynt  
 Coition ; yet I see not why our Saviour  
 may not be called the Seed of *David* and  
 the Seed of the Woman too ; for as to the  
 first its certain, the Seed of *David* vivified  
 the Animalcule, if it proceeded from the  
 Female, and the Solar, was the efficient Cause  
 of his Offspring: And supposing the second  
 Case, that the Animalcule is not from the  
 Female but the Male, yet he may be said  
 to be the Seed of the Woman, because he  
 had his Conception from her. ~~Thought~~ If  
 we take the Word Seed in the Sense of  
 Natural Generation, it cannot well be ap-  
 plied to him, and yet does no way con-  
 tradict the Doctrine of Animalcula in Male  
 Sperm'; for as his Conception it self was  
 miraculous, so likewise was the manner of  
 it too, and solar, without the Provinces  
 of Anatomy and Philosophy to account for  
 it, therefore can be no valid Observation  
 against *Leuzwenboek's* Hypothesis; yet it fol-  
 lows not that he took no Part of the Vir-  
 gin, for he had his Body nourished by hers,  
 and so became of our Nature ; and I *query*  
 if that is not all that is meant by that Scrip-  
 ture Expression, when he is stiled the Seed  
 of the Woman ; then if so, the one Part of  
 the Objection is answered, and as to the  
other

other, concerning his Stamen, how that was, and how it entered the Virgin, is not for us to know; and as little said is soonest mended, I shall beware of saying any thing rashly, but leave such Mysteries to God, who alone knows them; and always prefer sincere Truth before speculative Knowledge in such Cases, only observing thus much concerning it, that as he had no natural Father, let the Case be as it will, in either of these forementioned Ways, yet a Miracle must be wanting to produce that Effect; therefore to me it seems to relate to the Stamen, however that was.

Again another Objection, and of a different Nature to the former, against the Doctrine of Animalcula in the Male Sperm, they fetch from the Production of Mules; whence they think, were their Stamina, in the Male or Female, entire before Conception, it must necessarily follow, that there could be no such Thing as Mules, but must either be all Horses or Asses, according to the Species whence their Animalcula proceeded; and likewise we see Children that resemble both Father and Mother, and some again only one, or neither; which could not be, say they, if the Animal was determined beforehand. In answer to which, there needs no more, than only considering, how the Stamen may be acted upon by the material Juices which

Another  
Objection  
against *Leeuwenhoek's*  
Doctrine  
answered.



which pass and repass through it, which certainly will impress Features on the Animal, according to their Temperature; and consequently produce such various Effects as we see upon the Child when born. That it is very possible for these Effects to proceed from such Causes, is evident, do we but consider an Animalcule or Stamen in its prime Bigness, which, as we shall shew, is less than the smallest Grain of Sand; and then conceive its Expansion by the Addition of nutritious Particles between those staminal Parts, sufficient to encrease it to the Dimensions of a Foetus new born, we need not wonder at its Appearance, tho' we cannot, like Bricklayers, exactly tell how every nutritious Atom adds to this Formation; but that it is so, is plain from Observation: For, how much does Sickness alter the Features and Proportion of our bodily Parts, by wasting those nutritious Particles, and leaving the Interstices of the Stamen, as it were, bare and unclothed. Really I think the Case is so plain, that it would be needless to say more about it; for though the Shape in general takes its Origin from the Stamen, when the Creator formed it at first, and retains it through all its Stages of Existence, yet what it receives by way of Nourishment, can, and does make some Alteration in different Stamina, from certain Laws of Motion,

tion, too minute to be discovered, is very plain to any one that understands but ever so little of Philosophy. And here I could run into a great Length about this Matter, but that I strive for Brevity, and so shall pass to the Third; and in my Opinion, the true Hypothesis of the Mode of Generation.

The Third Opinion of the Mode of Generation is, that the Stamina of all Animals are pre-existent before Conception, in the Male Sperm; and that this is really so, we may reasonably believe from the great Discoveries that *Leuwenhoek* hath taught us by his Microscopes; whereby he hath found an incredible Number of Animalcules swimming in all Male Sperm, with very brisk Motion, like so many Tadpoles: And he further observes, that their Motion is languid in all Venereal Persons, proportionably to the Strength of the Disease; and that they recover their Motion again as the Distemper goes off; and that when these are wanting, Barrenness always ensues: Nay he goes so far as even to number them, and says that one Grain of Sand, whose Diameter is 1000th of an Inch, is larger than 3 000 000 000 of them; wonderful indeed, and yet it may be true, if we consider well the Divisibility of Matter; when it will appear very possible, for one of those minute Particles, as they seem to be

The Doctrine of Animalcules in the Male Sperm fully proved.

*Vid.* Philo-  
sophical  
Transacti-  
ons, N<sup>o</sup>.  
194.

be, an entire Animal, furnished with all its proper Instruments for Life, Motion and Procreation, and also the Fluids whereby it is nourished, though indeed so small, that no Power of human Imagination seems capable of being extended to. Now that Bodies of all sorts are compounded of infinite Numbers of small Atoms, is evident in that Case of Glafs of Antimony, one Ounce of which can furnish a Particle to each Particle of a Quart of Wine, and yet loose nothing sensible of its Weight; not to say any thing of the Particles of Gold, which Dr. *Halley* hath shewn, that one Grain of it may be cut into 10000 insensible Parts; and of other Bodies, that become so small when dissolved in proper Menstruums, as to become invisible, till precipitated by mixing other Liquids with them. How wonderful also are the subtle Effluvia that come out of a Loadstone, or exhale from odoriferous Bodies, as *Asa Fætida*, and the like; the Smell of which a Man is able to perceive at many Foot distance from the Body, therefore all the Air between must be impregnated with them; so that the Number of those Atoms, to fill such a Space, must be almost innumerable; and what is still stranger, the Body wastes very little or nothing of its Weight. But above all, most wonderful are the inconceivable smallness of the Particles of Light,



## I N T R O D U C T I O N.

418660<sup>12</sup> of which, as a great Man ob-  
 serves, will fly out of a burning Candle  
 in the Second of a Minute: And Mr. *Leu-*  
*wenhoek* tells us, that one Drop of Water  
 may be divided into 26 000 000 of Parts;  
 and that upon dipping the Point of a Needle,  
 it will lick up and suspend 13000 Particles  
 of Water on its Point. But not to be tedi-  
 ous, since we see the Divisibility of Water  
 is so great, surely it will be no Absurdity  
 to think, that each of those little Crea-  
 tures seen moving in all Male Sperm, are  
 so many intire Animals of those Species,  
 involved or rouled up, as it were, like a  
 Clew of Thread; for as small as it appears,  
 being afterwards filled and expanded by nu-  
 tritious Juices, at Conception from the Fe-  
 male, it becomes, in time, a large Animal  
 of common Stature. Nay, more than this,  
 some of the Learned have gone so far, as  
 to maintain, that each of these small Sta-  
 mina contain another within themselves,  
 and they others within themselves, and so  
 continually forwards to the end of the  
 World; whence it truly followeth, that  
 all Animals (and Vegetables) whatsoever,  
 were actually formed, and formally con-  
 tained in their original Parents; so we may  
 be said, in the literal Sense, actually to  
 have fell with *Adam* in his first Transgres-  
 sion: I say, we may have all proceeded  
 from one Man, and were once actually in  
 the

*Vid. Mr.*  
*Nieuwan-*  
*tyt's Reli-*  
*gious Phi-*  
*losophy.*

## INTRODUCTION.

the Loins of our first Parents; and have been ever since growing to our present State. Now, though the weak Imagination of Man cannot possibly represent to itself such an inconceivable Smallness, and Number of Animalcules, yet there is nothing in it that implies Absurdity or Contradiction, but so far from it, that we shall shew presently, that, of necessity, according to the Laws of Nature, it must needs be so: I say again, it carries nothing of Absurdity or Contradiction along with it, therefore is possible to be performed by the infinite Power of the wise Creator; and as for those who would be better informed of the great Divisibility of Matter, and the Probability and Possibility of this Hypothesis, let them consult *Leuwenhoek, Keil, Boyle, and Nieuwwantyt.*

No Anima  
produced  
mechanically.

Next I shall endeavour to prove to you, that it cannot possibly be otherwise than as here asserted. For it is highly inconsistent with the Laws of Mechanism, for to suppose an Animal ever so mean, little or despicable, can be delineated out of a little fluid Matter of our Bodies. For as the Heart is the Cause of the Motion of the Blood, and the Motion of the Blood, by urging the nervous Juices into the Fibres of the Heart, is the Cause of the Motion of the Heart; it followeth, that no one Part can exert without or before another,  
and

and therefore must all at once ; which no Matter, under any Laws of Motion, can bring about ; therefore must owe their Formation to a superior Cause ; wherefore as it is impracticable by the Laws of Matter and Motion, and too hard a Problem to be solved from so few Data, to produce an Animal, with all its Organs, in such nice Finess and Order, as is necessary for so many Actions and Offices, we may be assured, that it proceeded from a pre-existent Animalcule, and that Father and Mother conduce nothing towards its Being but proper Habitation and Nourishment, in order to make it able, in due time, to bear the Light and Air. Another Argument I bring from the Seeds of Plants, where may be found, in every one, that is not too small for ocular Inspection, a fine Stamen or Plan perfectly formed, with its Branches and Lines nicely foulded up, and guarded with proper Coats or Membranes to defend it from external Injuries in Miniature, just as the Animalcula are in the Male Sperm ; and the Vegetation of the Ova, and Incubation of, or Conception of the other, are only the expanding or unfolding of their Branches and Vessels, by the Force of their circulating Juices influenced by the Power of that, and the Rarefaction of the Air ; and that Growth or Nourishment is no more than the Accretion of the heterogeneous



neous Particles of fluid Matter to the Solids or staminal Atoms. Now, were there no more nor better Arguments for the intricate Pre-existence of the Animal, than this bare Analogy between the manner of Generation and Vegetation, it would be, to a considerate Person, who observes the Simplicity and Uniformity of Nature in all other Works, sufficient without any further Proof. But again, if we but consider the Infinity of Vessels and Fibres in one of the least of these Animals, their great Intricacy and Exactness to each other, their particular Necessity and great Use, we may, from our own Reason, easily draw this Inference, that no Matter or Fluid, under any Motion, can by any way whatever frame, all and each of these delicate Canals and winding Fibres, in such wise Order and Form, as they are in; which do evidently relate themselves the Handiwork of God; the very Thought of which Contrivance, to a thinking Person, is enough to ravish ones Soul with Admiration and Delight, seeing so far into the Nature and Source of our Being; than which Work, nothing can be, in this World, a greater Demonstration of the Power of *Jove*, or more glorious to Mankind.

Granting then that the Case is so, that all those minute Tadpoles, like Particles  
seen

seen in all Male Sperm, are such Animalcula as we have been discoursing of, with all, and every Part of their Bodies existing in Miniature; then all those Disputes and Queries, about the Formation of the Body, and the Priority of some before others, and such like Doubts, that antient Anatomists were so much puzzled about, are all cleared and answered at once; the Solids not existing before the Fluids, nor these before them, but both began together, by the Power and Wisdom of the great Creator, at the time he made Man at first: And what is very wonderful, but yet true, however it may appear to a Mind not versed in such Ways of thinking, is, that as they were all created together, likewise they were lodged in the Loins of their first Parents, and had a Circulation of their Juices, all one as when born, only with this Difference, that their Velocities were but small, just in proportion to the smallness of their Bulk, and tenderness of their Vessels or Fibres. And as they had a Circulation of their Fluids, so consequently must they suffer a proportionable Waste of them in time; and therefore they are placed in a fit Fluid for these Uses, the *Semen Masculinum*; where they continue in their imperfect State, till conceived by the Female, they are fitted with other Ingredients suitable to their Growth and quicker Nourishment.

C

But



*Vid.*  
*Drake's*  
*Anatomy.*

*Vid. Virhe-*  
*gen. Part*  
*II. p. 69.*

But as this is a very nice Point, to prosecute the Theory yet a little further, cannot be unacceptable to the Reader ; therefore I add this more, that as these Tadpoles are only to be seen in the Semen, and no other Juices of the Body, it still confirms it the more, that they are so many Men and Women, and not some grosser Parts of the Solid only, as Dr. *Drake* has supposed. For how come these grosser Parts to be alike in Shape ? How come they all by those long Tails, and round Heads they appear with ? And what makes them delight in their ludicle Motion ? These Queries can no ways be solved from the Nature of larger or grosser Particles suspended in the Seed ; therefore that cannot be the Case. And not only *Drake*, but *Verbeegen* asserts, that they are only Particles put in Motion, and not the Stamina of living Creatures ; and supposes them to be some active Substance, suited to propagate and maintain the Laws of the required Motions, in the Female Ova, like Fire or Yeast, that move their particular Bodies according to their own Laws ; for the Defence of which Fancy, he relates an Observation of Mr. *Hartfoker*, That this moved Matter, in *semine Masculino*, does preserve its Motion some Hours in the Cold, but in the Heat soon disappears ; whence he concludes, they cannot be Stamina, but Parti-



Particles, it agreeing with them better, to co-operate with Heat than Animalcula, which so much stand in need of it. But though the Observation be true, yet I can see no Reason for his Inference; for it may be, and probably is so, that all extraneous Heat may be hurtful to their Tenderneſs, by reason it cannot act on them, ſo even and regular as that of the Parent's Body; or perhaps may proceed from the too great Rarefaction of their Menſtrum, when expoſed to external Heat; ſo that they cannot take ſuch Strokes with their Tails, as to agitate their Bodies as before. But whatever may be the Cauſe, it is too raſh to pronounce from thence, that they are not Animalcula, unleſs we knew certainly, how many Ways their Motions may be diſturbed, and by what Cauſes: So that, make the beſt of this Objection we can, it will come to no more, than a bare Suppoſition. But what we have already ſaid above, is ſufficient to ſhew, to any that will yield to Conviction, how juſt it is; therefore I think we may reaſonably conclude, they are ſo many Men and Women, that appear under the abovesaid Make or Exiſtence, and particularly endowed with Qualifications, that are no ways applicable to any Matter, under any kind of Motion whatever. Therefore, as Holy Writ ſays, that Heaven, Earth and the Sea, and all

that in there is, were created within the Six Days Creation, we can give no later Date to the Origin of these little Men or Women, than that of *Adam*; and consequently were convey'd down actually from Age to Age, till it pleased God, of his Providence, they should, in Time and Order, see Light.

Why Animalcula appear in the Shape of Tadpoles.

Here some may query, That if these seeming Particles be so many Men and Women, Why do they not appear as such? but instead thereof, are like so many Tadpoles. In solution of which Question, we are to consider, that Nature hath carefully secured them, with Walls and Inclosures, to guard their most tender Frame from all external Injuries, which otherwise they would often be in danger of; therefore they are furnished with a fine Membrane, that envelopes their curious Members, and defends them from the Acrimony, and the like depraved State of the Semen; helps them in their Motion, and prevents their losing a Limb, by intangling their Parts with one another: And that this Membrane, from whence they derive this Form they appear in, is of great and general Use, is plain, since that all Animalcula, of all Sorts and Species whatsoever, equally have it, and the Extremity of this bag-like Membrane, being prolonged some Distance from their Body, constitutes the Tail; which, like a Rudder,

Rudder, serves to direct and move themselves by, with great Quickness and Agility; a nice Cut of which, may be seen in *Vid. Chisel-*  
late Author, my ingenious Master, un-*den's Ana-*  
der whom I studied Anatomy some Years *tomy.*  
ago.

The Truth of this Theory we learn from *Why the*  
Frogs, and for the Knowledge of it, we *Frogs go*  
are beholden to that Species; who, by *not their*  
reason of their great Use for Food, both *Time.*  
to Birds and Fishes, Nature hath ordered  
that they shall encrease and multiply ex-  
ceedingly, as we daily see they do; one  
She Frog voiding many Hundreds, if not  
Thousands of them at one Spawn; and thus,  
they being so many, she is not capable of  
retaining them in her Body, till arrived at  
Maturity and their last Shape; for that  
would unavoidably burst her: Therefore,  
she is forced to eject them on the Water,  
as soon as they become troublesome to her;  
and so we come to see them in their first  
Form; and in this Shape and Figure, they  
remain some time after Birth, till by grow-  
ing larger by Nourishment, their Bodies  
distend, and fill up this loose Part of the  
Membrane, and then their Legs appear,  
and the Tails vanish: And, as I said be-  
fore, the Use of this Membrane, in their  
first State, is for a Defence to their tender  
Bodies, and to give them that spheradal  
Form that assists their Swimming; which



Membrane, forwards, is not annihilated, but perhaps constitutes the Cuticle that covers the Skin. Thus we see, that Frogs are Tadpoles in the Uterus; and all Male Sperm contains Tadpoles, exactly of the like Shape. Consequently then, our Stamina are so too, and do all proceed from the Male: For as it is so with all other Animals, it is no great Wonder, nor need we any ways doubt, but that it should be so in us likewise. But as Women are not oviparous Animals, we cannot expect to see Men born as young Frogs; though once their prime Figure was the same. And this we see holds good in Flies; for in Flies of all sorts we find, that the Egg of the Female first produces a Worm, and this Worm, though of a quite different Figure from its Parents, does, in time, change its first Shape into that of a Fly, according to its Kind. And thus we see, that this Figure of young Frogs, being so exactly like what we see in all Male Seed, does further confirm to us, the Truth of the Doctrine of Animalcula; and of their existing in, and proceeding from the Male only.

Again, one Argument more I may add, as a further Proof of this Theory, of Pre-existence of Animalcula *in semine Masculino*, which is this: Suppose a Man was to lose his Arms, Ears, Lips, Legs and Thighs;

Thighs; in short, all the Parts of his Body, but what are directly necessary for Life and Procreation; and the Woman he begot upon, be in the like Case; yet, his Children shall have all, and each Part of their Bodies whole, perfect and intire; though their Parents had them not themselves, and so could no ways communicate them to their Posterity. This wonderful Phenomenon can no ways be accounted for, but by this Doctrine of Animalcula, which supposes all their Parts to pre-exist, and be intire of themselves, and owe nothing to Father and Mother, but proper Place and Food. And indeed it cannot be otherwise, in as much as no Parent can any ways supply their Children with those very Members they wanted themselves: Wherefore, of necessity it follows, that as Children of lame People, always have those very Parts their Parents were deprived of; they took not them from them that were not able to give them what they wanted themselves, but come by them another Way, and from a quite different Cause; as we have shewn above, and shall more hereafter.

This very Question, how Children came by those Members their Parents wanted, when they begot them, hath greatly puzzled the best Anatomists, to this Day, to account for. The sublimest Invention of



*Diemer-  
broeck's A-  
natomy,  
fol. p. 195.*

any, that is not Truth, to solve this Matter, that ever I read of, is that of *Diemerbroeck*, where, in his Anatomy, he fancies the Ideas, of all the Parts, are contained in a small Particle of the volatile, or spirituous Parts of the Seed, which it receives from all, and every Part of the Parents Bodies, as it once circulated in their Veins; which lighting on a proper Subject, namely the Ova, it may be effectual out of itself, to produce and form a Body, like to that from which it received the imprinted Shapes; and when a lame Person (says he) wants any Part of his Body, so that the Child cannot have it the foresaid Way, it is then supplied by the Imagination of the Mother; which he pretends to prove in that Discourse, which would be too tedious, and to little purpose to rehearse here. Now the ill Philosophy, and immechanical way of Reasoning on this Topick, is sufficient, without further Trouble, to overthrow his Hypothesis, as being, by far, too metaphisical for such natural Enquiries; and therefore seem more reasonably to be solved, by that of the former, which explains every Doubt and Quere, of that Nature, very easily and intelligibly, without Rack, Incongruity or Absurdity. Hence likewise we have it, that that Quere, whether Males are begot by the Right Testicle, and Females by the  
Left,



Left, is very empty and ridiculous, without the least Ground or Reason ; besides, from what we observe, of those who have lost one Testicle, and yet begot Children of both Sexes ; since Animalcula are in both alike, and are Male and Female promiscuously, this therefore is owing to Chance only, or rather Providence, that causes this or that to be conceived. From all which it is plain, as aforesaid, that Parents conduce nothing to the first Substance of our Bodies, or Formation either ; but are only as a fit Repository for us, till able to bear the Air. Therefore, how low a Notion that Doctrine is, that supposes the Mixture of our Parents generative Juices, to form and delineate, such a fine and complicated Machine as our Bodies are, from a few Laws of Motion, is evident, by this Time, to any impartial Reader ; and he that is not convinced of the Truth of it, is very hard of Belief, and stands a Chance never to be convinced.

*Lastly*, To conclude this Discourse in all its Branches, we must consider another great and wonderful Phænomenon in Nature ; that is, how a Stamen or Animalcule, which at first contained less than one Grain of Sand, should be distended, unfolded or expanded to the Magnitude of a full grown Body of six Foot long. This indeed is wonderful, but very possible, if we consider

consider again, the divisibility of Matter; for those Particles of Matter, which constitute the solid or original Stamen of any Animal Body, are expanded by the Addition and Interposition of fluid Particles, that we take in by any way of Nourishment, which are no true Parts of a Mans Body, only serve to distend and dilate the true Solids into their former Dimension, and then fly off again by Transpiration or other Evacuations, when their Places are supplied with such nutritious Particles, which keeps the Body up to its usual Standard of Bulk: So the Increase of the Body is performed by these Interstices of the staminal Matter, being filled up with extraneous Substances, received at first in by the Mouth, and afterwards deposited in the Vacuities of the Fibres, as they pass along the Nerves; which Stamen, without this Addition, would be of its self, under such a Dimension, but as a mere Shadow. And something that will appear more wonderful to prove this, and yet the Possibility demonstrated, may be seen in Dr. Keill; where he shows, that not only a Body six Foot in Length, but even that unmeasurable Space, containing in its Circumference the starry Heavens, or a larger, if you please, may be filled and obscured, by the Dust of one single Grain of Sand, after such a manner, that not so much as one Ray of Light,

*Keill's Introduction to Philosophy, p. 64.*

Light, though never so small, shall be able to pass between the Parts of it. Thus we see it needs be no Wonder to us, that those small Particles seen floating in all Male Sperm, are so many organized Bodies, whose Parts are so delicate and subtle, as not distinctly to be seen by the best of Glasses, by reason that we can see no Body under any Angle less than a Minute ; yet, from what hath been said, and from what may be seen, it is certain they are such, and have Parts necessary for their Actions, as Fibres, Membranes, Arteries, Veins and Nerves, with the rest of them ; with all their respective Juices in them, whose smallness far exceeds the very Force of our Imagination : The smallness of whose Blood-Globules alone, which is one of the grossest Fluids in the Body, the above-mentioned Author says, 10,256 of the highest Mountains in the whole Earth, do not contain as many Grains of Sand, as one Grain of Sand can of the Blood-Globules of these Animalcules, and then goes on to prove it.

Now to recapitulate what hath been delivered on this Head : We see, that the Shape, the swimming Motion, and the Analogy that is between Plants and Animals, the Observation and likeness to Frogs, the Reasonableness and Philosophy of our Theory, all give their Vote for pre-existent  
Stamina,



Stamina, and for their proceeding from the Male only : Besides ocular Demonstration, which carries the most cogent Proof, and the universal Consent of the most Learned. What need we say more then, since a word to the Wise is enough, and all that can be bestowed on the wilful Ignorant, will be too little : For can any reasonable Creature, that gives himself Liberty to think, suppose that flat Form, those long Tails, their sudden Motion, and their constant and universal Appearance, can proceed from Matter and Motion; especially when he considers, that all action and effect of Motion in an Animal Body, is only the Separation of Juices, by several Outlets or Secretory Ducts, which can no way conduce to the framing such a compound Being as an Animalcule ; and as for framing it self, is a Thought, which I think none will pretend to entertain : Therefore, after all it must be before, and made known by a Power superiour to any Laws of Motion ; by God himself.

And if it be thus made by the immediate *Fiat* of God, as all other created Beings were, it must exist somewhere all this time ; and that Place was the Loins of the first Parents, whence it hath been transferred by successive Generation all our Days, and so continues to be the end of Nature. And thus we come to the clear Knowledge  
of

of those Passages, as speak of the Doctrine of Animalcula in Scripture ; as that *Levi*, together with all his Sons, was yet in the Loins of his Fathers Grandfather ; yea, and great Grandfather *Abraham*, when *Melchisedeck* met him ; and which is more, payed Tithes to him ; and if *Isaac*, *Jacob*, and the whole Tribe of *Levi*, were once in in the Loins of *Abraham*, we need not to doubt, but that we were all in like manner once wholly in *Adam* ; and consequently, are all propagated from him, not virtually, according to the old Cant, but literally and actually, according to the afore-said Theory. Hence, I might launch into the Origin of the Soul, and the Resurrection of the Body ; but as they are foreign from our present Purpose, we shall refer them to another Opportunity, if that we find this meets with a kind Reception from the Learned.

To pass by here the manner of Conception, and treat of it in a more convenient Place, we shall now shew what the Animal is in a mature State ; to do which aright, we must understand, that the whole Body is vascular, and that all the Solids are made up of an infinite Number of hollow Vessels or Canals, which are no more than a continuation of the Aorta and its Branches ; and their seeming vast Differences proceed chiefly from their different Diameters and  
Juices

Juices which they contain. Whence we find, that there is no such thing as a Paranchymous Substance in the Body, at the extremities of the Arteries, as was formerly taught; for where an Artery ends, there a Vein begins; and from the sides of the ends of the Arteries, either immediately or mediately, arise all the Vessels of the whole Body: So that as I said before, all the Solids are so many hollow Tubes, whose Basis is the Aorta at its Exit from the Heart; through which all the several Juices circulate, for their several ends and uses; which is Life it self; and are as followeth.





## CH A P. II.

### Of the H E A R T.

**T**HUS far, in the preceeding Chapter, I have discoursed of all the Solids in General, and considered them in the Stamen in Miniature. In this Chapter, I come now to view them apart, and consider each one by itself, and begin with the Heart, which is the Principal and Chief amongst them; which discovers itself first in the Embryo, and is the *Perpetuum Mobile* in human Bodies; the Fountain of Heat, Life, and Motion, without which we cannot subsist one Moment.

The Heart,  
its Mecha-  
nism and  
Use.

Its Mechanism is thus; It is a double Muscle, consisting of strong Fibres of various Directions, whose Tendons are in the Basis of it, and very short; for a mechanical Reason I shall give, when I treat of the Muscles. The Substance of it is very dense, and the Directions of its Fibres are of five Sorts: The first kind, run obliquely from Top to Bottom: The second, just contrary to them, and by that means intersecting them; by the contracting of which, the Cavity of the Heart becomes narrow, and its Extremities approach somewhat nearer each other: The Third Sort are straight, and only belong to the Right Ventricle, which

*Vid. Lower  
de Corde.*

which serve to shorten the same; they lie above the last mentioned: The Fourth, are proper to the Left Ventricle, which running on all Sides, from Top to Bottom, encompass the Heart at its Point, and serve to draw the same upwards: The Fifth Sort, lie under all these, and embrace the Heart all round, cross-ways, and assist the oblique Fibres in their Contractions; so that here is somewhat alike Mechanism in the Structure of these Fibres of the Heart, as there is in those of the Muscles of the Belly, and it is not possible, for any other Structure to have answered the End so well as this does; for, hereby is caused a very strong and uniform Pressure upon all the Blood in the Ventricles, whereby it is driven out with a Force sufficient to overcome all the Resistance from the Vessels, its own Gravity, and whatever may impede its Motion through the whole Body; and, as its Shape and Figure is not a Sphere, in which Case all circular Fibres would have been properest, but is something of a Pyramid Form, it is highly necessary its Fibres should be of various and different Directions; the exact Knowledge of which, and all its wonderful Parts and Powers, are beyond the known Mathematicks nicely to describe.

*The Papilla  
and Colum-  
na, their  
Mecha-  
nism and  
Use.*

But besides this so well adapted Structure of the Heart, from its Figure and Fibre's

Directions,

Directions, there are other Remarkables belonging to it ; they are the many *Papillæ* or *Columnæ*, to which the last are fastened at both Ends, and cross the Cavities in the Heart, and serve as so many Rafter's or strong Beams, to prevent its over Distraction upon violent Diaστοles ; or the total breaking or bursting of the Heart, and, by their Elasticity, to assist the other Fibres in contracting. If any of these should chance to be broke, a small Aneurism would be caused, as I may call it, in the Heart, and its Circulation retarded.

The Heart hath two Cavities or Ventri-  
cles, separated from each other by a  
thick and strong fleshy Partition, called  
the *Septum*, which are very unequal on  
their Surfaces, and differ in bigness, the  
Right being widest, but the Left longest and  
narrowest, and its sides stronger and  
thicker ; the inside of which properly con-  
stitutes the *Septum medium* ; the Reason of  
which is, because the right Ventricle being  
so wide and lax, gives easier and freer Re-  
ception of the Blood retarded in its Motion  
in the *Vena Cava* ; and as it propels the  
Blood only through the Lungs, it need not  
be so dense and strong as the Left, which  
throws it through the whole Body. For  
which, and that it might perform its Action  
the better, it is placed or situated in the  
middle of the *Thorax*, where it can con-  
vey

Why the  
Ventricles  
are not  
alike in  
Bigness  
and  
Strength.



vey its Force and Influence equally thro' every Vessel, according to their particular Need or Exigence, which was it fixed higher or lower in the Body, the Brain would have too much or too little Blood, and so of the inferior *Viscera*.

By this time we see, how frivolous that hot Dispute amongst Anatomists was, whether the Heart is a Muscle or not. *Hippocrates* and *Steno* were for the Affirmative of it; but many others denied it; but the very Rehearsal of those antiquated Notions are odious to them that are acquainted with modern Learning and Improvements. But the Question may be easily solved without prolixity, if we rightly consider the Nature of the Heart, and that of a Muscle where we find the Fibres alike, only the first much stronger. Again, consider the Motions; the material Causes are the same and their Effects the same, *viz.* Motion, and as for their difference in Shape and Figure, it gives no more Cause to deny the Heart to be a compound Muscle, than to deny several Muscles of the Body to be such, that have nothing of Figure to some others of them; so that the only and chief Difference consists, in that the Motion of the one is voluntary, whereas in the other it is involuntary. Whence we see such like Disputes are more about Words than Facts, and as such we leave them.

Further

Furthermore, the course or circulation of the Blood, which continually passes thro' the Veins into the Heart, seems to require, besides the foresaid Cavities, a resting Place by the way, to be contained in, during the Contraction of the Heart, where there are the little Bags adjoyned at the Orifices of each Ventricle, made of an Expansion of the *Vena Cava*, into which the Blood enters at first, and is there collecting, whilst the Heart is performing its Systole; and as soon as the Heart opens again, the Blood rushes first and directly into the said Ventricle, together with a continued Stream. Whereby it appears, that more Blood enters the Ventricle of the Heart, than what the Auricle can well hold. Hereby the Circulation is carried on with an equal uniform Motion, which without these Auricles, and this Mechanism, must have stopped a little at the Heart upon each Systole, which would have retarded the Motion of the Blood a little, every Pulse, and so become very troublesome, and at last fatal. These likewise are defended with many Columnæ, as we said of the Ventricles. In the right Auricle lies the Orifice of the *Foramen Ovale* in Infants.

The Auricles, their Mechanism and Use.

The most remarkable piece of Mechanism belonging to the Heart, is its several Valves. In the right Ventricle there are three, called from their Figure Tricuspides, having

The Valves, their Number, Situation, and Use.

having their Basis fixed at the Mouth of the Ventricle. They admit the Blood to enter, but, upon the Contraction of the Heart, shut like Flood-gates, and form a concave Cone, that hinders its return to the Auricle again ; wherefore it rushes *quodammodo data porta*, out at the Pulmonary Artery. There are also three more called Sigmoidales, that surround the Entrance of the Pulmonary Artery, suffering the Blood to pass by in its direct Motion, but shuts the Passage if the Blood offers to return back into the Heart again : These are all the Valves on the right Side ; there are just so many on the left : The first three called Mitrales, which are placed at the entrance of the left Ventricle of the Heart, as the Tricuspidales, are at the right, and for the like Use as they : The other three are the Semilunares, which are situated at the beginning of the *Aorta*, just as the Sigmoidales are at the beginning of the Pulmonary Artery, and serve for the like Use ; that is, to prevent the Blood's returning back, at any time, into the left Ventricle again, after it is once expelled thence. Thus we see, the Heart is a wonderful Machine like unto Syringes, serving to propel the Blood over the whole Body, and so is the fountain of all our Heat and Motion. These Valves likewise serve as so many Valves of a Piston, to hinder any Regress



of the Fluid the wrong way. Their Texture consists of Membranes, that they may be more pliable, and are fastened to the sides of the Ventricles with many tendinous Fibres, the better to resist the recurrent pressure of the Blood.

The Heart, I say, is the principle Part, the *Primum Mobile* of our Body; the fountain of all Heat, Motion and Life; for which reason it is larger in Men than in other Animals, in proportion to their bigness. And for this reason it is, in holy Writ, that the Heart is mentioned instead of the Soul, or our whole Affections; it being the most noble Part, and, in its very Figure, bearing the bright stamp of the Deity that made it. It is supported by the Blood-Vessels, *Pericardium* and *Mediastinum*, with its Point a little inclined to the left Side, to afford the more conveniency for the ascending Blood from the *Vena Cava* inferior, to enter the Ventricle; for, as an Author observes, the Blood, like other Liquors, will rise to the same Height in both Legs of a reflex Tube; for the same Reason the *Aorta* runs first upwards, before it turns down, that the force of the returning Blood from the lower Parts, may be greater in the *Vena Cava*. Its Extremity is covered with a proper Coat, which is very thin, but exceeding dense, the continuation of which, forms the external Coat

*vid. Keills  
Anatomy,  
Anatomy.  
p. 180.*

of the Aorta, and all the Arteries; and the Internal Membrane, that lines the inside of the Heart constitutes the inner Membrane or Coat of the said Arteries; in like manner, the Nerves as we may say, are furnished with Coats from the *Dura* and *Pia Mater*, of which hereafter.

The Peri-  
cardium,  
its Struc-  
ture and  
Ufe.

Again, were the Heart, notwithstanding its nice and so well adapted Structure, to be thus left, without any further Security, it would soon become uselefs, and its Fibres growing so dry, would not be able to corrugate and contract themselves, therefore Nature hath provided it with a furrounding Membrane or Bag, which, by furnishing it with a fine, thin, limpid Liquor from its small Glands that line its inward Fold, do continually moisten it, thereby making it smooth and fit for the better Performance of its violent Motions. This *Pericardium* is a thick Membrane like a Purse, and is perforated in five places, for the passage of the Vessels which enter and come out of the Heart. It adheres to the *Mediastinum*, its lower end sticking to the Center of the *Diaphragma*; which *Bartholine* says is peculiar to Men, and not in other Creatures, for they have it loose; the Reason of it I take to be, because we are more subject to various Postures of Body than they, and to bend our *Thorax* downwards, which they do not; therefore

it

It is convenient to keep our Hearts in a steady Posture, whatever the rest of the Body be in: The Use of it I say, is, to separate and contain a serous Liquor, to moisten the Heart. Some think, what is found in this Enclosure, which is generally about a Spoonful or two, proceeds from condensed Steams or Vapours that exhale from the Heart, and are collected here into a Liquor, which is carried away again by Lymphaticks, that absorb what is superfluous; but this is no way plausible, for it seems rather that the great dryness and heat of the Heart, should require more Liquor to keep it supple than it can possibly afford it self by those Steams; it being besides of so dense a Substance, as not to let any pass that way; and we have no Instance in the whole Body of any Liquor so generated. But those that would be better informed may see *Malpighius*, who hath discovered small Glands in this Membrane, which separate this Liquor for that Use: But above all, I think it less probable, as some assert, that this Liquor was not designed for Use, nor contained here in Life time; but is only the effect of the strong Convulsions of a dying Heart, as a famous Gentleman supposes; for were it so, that the Heart was without it before, then it would be in such a Case as I said above, and supposing not quite so badly



off, yet by being continually dry, the Friction it would undergo, would wear its Fibres dry and hard, as well as those of the *Pericardium*; unless you hold and suppose that they never touch, which cannot be avoided. But whether it be so or no, I am apt to think it might be determined and proved, and without Dispute discovered, by dividing or cleaving a Dog in two in a Moment, and quickly inspecting the *Pericardium*, before those dying Agonies could have Time to produce that Effect. But the different Colour, Consistence and Qualities in Diseases, that have been found in Patients, upon opening the *Pericardium* after Death, I think do plainly show, that it existed there when alive and well; besides, that Instance of a wonderful Quantity, that was found in an *Englishman's* Body, at least two Pints of Liquor, confirms me the more in this Opinion.

*Vid. Diemerbroeck's  
Anatomy.  
p. 304.*

Thus much we have said of the Remarkables of the Heart; and to add one thing more, I come to take Notice of its Situation more particularly, passing by many things that are meer Guesses, and some not yet found out. As to its Situation, all Men know it is in the *Thorax*, but all Men know not, why it is placed there rather than in another Situation or Part of the Body. The Reason is twofold; in respect of the Lungs, and in respect of itself. With  
regard

regard to the Lungs, because no Place could be so fit for them as this Cavity, since the Blood must run through them immediately after it leaves the Heart, both because it is there fittest and ready to be impregnated with nitrous Particles from the Air, and because the Air itself can be received in largest Quantities in this Cavity, to keep up the Circulation of the Blood, by its Elasticity and Pressure. Again, upon the Account of the Heart, it is the most convenient Part to be situated in, because from hence it can spread its Influence uniformly over the whole Body; whereas, were it placed in the Head, or *Abdomen*, its Arteries must have had another Frame, to carry the Blood to every Part, in proportion to their respective Exigencies; and for this Reason it is, that Brutes that walk prone, have their Hearts more in the Center of their Bodies; whereas, we that walk erect, have our Heart nearer our Heads, that the Blood may be equally distributed, by gaining that Advantage by its Proximity to the Head, which it otherwise loses, by the Gravity of such a heavy Fluid in ascending upwards.

Our next Observation is, concerning the Motion of the Heart; which is twofold, *viz.* its Contraction and Relaxation: The first is called its Systole, the other its Diastole; both which go to every Pulse; the

The Circulation of the Blood, how performed.

Blood

Blood being propelled by the one, and let into the Ventricle afresh by the other; which being constantly repeated, continue the Blood in its Motion and Circulation; which is very Life itself. And whatever Cause it may be, that can suddenly stop, or gradually impede those Motions of the Heart; whether by Suffocation, high Fevers, or too large Evacuations, it will certainly occasion Death. The right manner how the Heart continues this Motion, is after this way: Suppose it once set on contracting, that propels the Ventricle full of Blood into the Aorta, and through every small Vessel, to the Extremity of it; and not only thither, but even back again by the Veins, and so into the right Auricle and Ventricle, where it is assisted by the Pressure of the Atmosphere; but as the Heart cannot move of itself, and it is not the Blood that causes it to do so, we must consider another Particular, before we have a right Notion of Circulation; and that is, the nervous Fluid, which at every Contraction of the Heart, lies ready in the Nerves belonging to it, to drop afresh into its Fibres, to cause a fresh Contraction; and this Motion it hath from the Pulsation of the Arteries upon the Brain, and moves so, that as the Blood moves the nervous Juice, so that moves the Blood; and their dependence is so exact upon each other, that as

the



the Strength of the one is, so is that of the other: And thus, by this repeated Motion of Blood out of the Ventricles, and Spirits or nervous Juice into the nervous Fibres of the Heart, which causes a Contraction to be repeated, the Motion of the Heart, and Circulation of the Blood is continued, till the Period of Life ensues, from bare Age, or some Mismanagement that happens to interrupt this regular Order; so that the Heart hath lost one actual Motion, and that its Dilatation or Diastole, is merely an Effect of the Bloods rushing into the Heart, when empty so, is surely passive.

The Motion of the Blood is not called Circulation, as if it made a true Circle, for that is impossible; but because the Blood hath once begun to move from the Heart, to the Extremities by the Arteries, and returns again thence to the Heart, by the Veins, without Intermission, as long as the Animal lives; and this is called Circulation; for the Knowledge of which, we are beholding to the great Dr. *Harvey*, who was Physician to K. *Charles* the First; and it is probable, had its Master lived longer, we had known more.

Wherein the Motion of the Blood is circular.

The Motion of the Heart then, is the Cause of Life; and when that stops, no Power can set it in Motion again, but he that first made it; which gave occasion to that Saying, *That the Heart is the first Part*

The Heart, the chief and only Agent in Animal Bodies.

of

of the Body that begun to live, and the last that died. It is from him we have our Heart ; by him Secretion is performed, in the regular Performance of which, Health consists ; and in short, through him, under God, we live, move, and have our Being. But yet, so ticklish is our Life, that for all the many wonderful Provisions against Danger, we could not long subsist, were there not one Addition more, and that is, the *Tuberculum Loweri*, which is a small Eminence, or Protuberance, in the Origin of the *Vena Cava* ; and as it is highly necessary, towards the Circulation of the Blood, we mention it here ; for as the Stream of Blood descends from the *Vena Cava*, and meets with another Stream, from the same *Vena Cava* ascending ; these two Canals, rushing against each other, would cause a great Stoppage in the Blood's Motion ; for from the third Law of Motion, Action and Reaction is always equal and contrary ; and consequently, the result of this would be an end of Circulation : To prevent which Inconveniency, between these two foresaid Veins, there lies a Protuberance composed of Fat, which grows under, against which the descending Blood strikes, and thereby hath its Course turned to the right Auricle, whilst the ascending Blood, is, by the said Protuberance, secured and covered, against the opposite Course of the former ;

former ; and that this is so is plain, since it is larger in Man, than in Brutes, by reason of his erect Posture ; the upper Blood in him flowing directly perpendicular.

Lastly, as to the Cause of the Heart's Motion, we have given an Account already ; let us now enquire into the Cause of its first Motion, or the first Cause of its Motion. And here, at once, we are in a great Dilemma, how or where to begin ; but as it owes it not to natural Causes, so we must not pretend to deduce it from them, but freely own God as the prime Cause of the Motion of our Hearts, and that was when he created us, and placed us in *Adam's* Loins, from which Time it hath kept moving to this very Day ; for as absurd or miraculous a matter however it may appear to be in the Eyes of the Ignorant, here we have a clear Notion of the Motion of the Heart, and Pre-existence of Animalcula. Hence we see the weakness of former Opinions, which supposed the Heart to take its Motion from Animal Spirits, Expansion of Blood in its Ventricles ; and others from a Motion of both : Some would have it proceed from ethereal Matter, or from the Respiration of the Lungs. Without further Prolivity, so tedious and confused are the Doctrines and Fancies of Authors about it, enough to nauseate one to read them. ' Thus we see the Cause of the

The first  
Cause of  
the Heart's  
Motion.

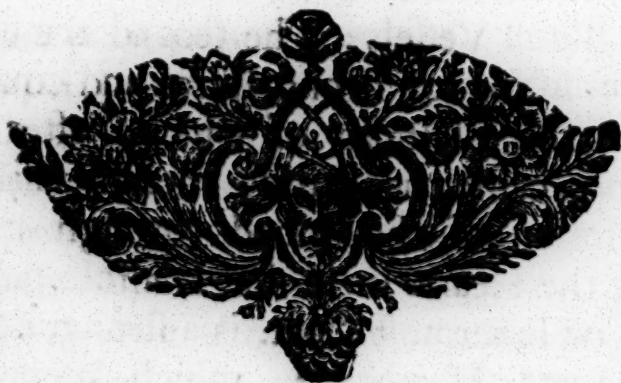


the Heart's Motion, as it is now performed, is not so hard a matter to know; nor even how it first came by it; such is the Advantage of Learning, that it makes deep things familiar to us, and even forces Nature to reveal herself.

In the next Place, we should proceed to consider the Quantity and Velocity of the Blood, which would naturally follow, but we reserve that for its proper Place, in the Second Volume, where we treat of the Fluids only. To conclude this Chapter then, we see clearly the Use and Mechanism of this Noble Part, and what relation it bears to an hydraulick Engine: How it causes the Pulse, and how far the Instrument and Means of Life. And, as these things cannot be determined without the Knowledge of Mechanicks, we may see how necessary they are in the like Enquiries; for it is from the Motion of the Heart performed in due Strength and Equality that makes the Blood flow into all the Parts equally, and have equal Quantities secreted in equal Times, according as their Differences require, which is the Standard of Health itself, without which, the Body is, at the best, but in a sickly State. And as the Heart is a mechanical Engine, or Power, so are all the rest of the Solids, in proportion to their Structure and Use, in every Part of the Body, and as such must be

be examined and considered, by any that pursue the true Indications in the cure of Distempers: For some are Supporters or Pillars; some of the Solids are Coverings and Partitions, Leavers, Rowlers, Wedges, Pullies, Cords, and Presses; Bellows, Sieves, Strainers, Canals and Cisterns; which act agreeable to the Laws of Mechanism, and by which only they can be explained.

To conclude, as to the Nourishment of the Heart, we shall only add, in short, that the Heart is not nourished by the Blood that is received into its Ventricles, but by the Mediation of the coronary Arteries, which run round its Substance; and its Veins come out and enter the *Cava*, just as it enters the Heart.



## C H A P. III.

*Of the* A R T E R I E S.

Of the Ar-  
teries in  
general.

**W**E have said before, that the Body is nothing else but a congeries of Canals. In this Chapter we shall treat of the more remarkable Ones, *viz.* the Arteries; and thus much in general. The Arteries are all like unto a concave Cylinder, whose Basis is the Orifice of the *Aorta*, at its *Exit* from the Heart, and serve to carry, or transfer that heterogeneous Fluid the Blood, to every single Part of the Body, for its Heat, and to answer the Intentions of Secretion. They consist, all of them, from the largest to the smallest, of three distinct Coats or Membranes. The first, which is external, is nervous, and full of small Blood Vessels: The second is muscular, consisting of strong spiral and circular Fibres, the Elasticity of which, after Distention, cause the Pulse; thereby assisting the Motion of the Blood through them, whilst the Heart is in its Diastole. The third, or innermost Coat, is a strong, dense, transparent Membrane, which keeps the Blood within bounds; when this happens to be corroded, or ruptured, an Aneurism directly ensues, which will distend the other two Coats, inconceivably wide. These

Coats



Coats grow thinner, as the Arteries grow smaller, till, at the last, they terminate in a conical Figure, and change into Veins; and all these Coats, we may say, they derive from the Heart, as the Nerves do theirs from the Brain; they being no more than the Elongation of the same. The Figure of all the Arteries, even to the minutest of them, is circular; and this must follow of necessity, by reason of the Pressure of the Fluids that circulate in them; it being a known Law in Hydrostaticks, that Fluids press *undiquaque*; therefore as the larger Vessels are of that Form, the lesser ones must be so too, according to the said Rule; and if so, we may truly infer, that different Secretions arise not from the different Figure of the Orifices of the Glands, as some have thought, for as much as they are all circular, as may be seen in Dr. *Pitcairn*, proved mechanically. But not to anticipate our Design, we shall refer a further Discourse of this, to its proper Place.

*Vid. Pitcairn, de motu sanguinis. p. 52.*

Thus far of the Arteries in general. We shall now examine them singularly, and follow them in their Course, where we shall find several Curiosities in their Mechanism. And here it is not to be expected, that I should run into the deepest Curiosities of Mathematicks, as I write what may be intelligible to those that are not much acquainted with such Studies. The Vessel,

*Of the Arteries in particular.*

E

or

or Canal that offers itself to our Consideration, is the *Aorta*, which arises out of the left Ventricle of the Heart, and mounts upwards first, for a Reason we mentioned before, and then divides into two, the ascending and descending Branches. It much exceeds all the others, in Thickness, Breadth, and length of Course, being the Original of the rest, which as it proceeds, is divided into many lesser Branches, which again are subdivided into many smaller than they, and so on, *ad infinitum*, there being no separable Part of the Body, that is totally without them; The more remarkable Branches of which, are these following. The first are the two coronary Arteries, which they emit before it proceeds out of the *Pericardium*: They are called so, because they do not immediately enter the Substance of the Heart, but take a Circuit on the Surface, or Basis, like a Crown; and this they do, that they may the better branch themselves towards its Cone, and moderate the too violent Motion of the Blood into its Fibres.

The *Aorta*, having penetrated the *Pericardium*, constitutes a large Trunk, the smaller part of which ascends upwards, and forms the ascending *Aorta*, and the larger Branch goes downwards, and frames the *Aorta* descending. Out of the first and superior Branch of the following arise, the subclavian Arteries, and the Carotids. The Right Subclavian being higher and larger than

than the Left, propensates for its greater Distance from the direct Current of the Blood, as it comes out of the Heart and thereby not only makes its Quantity equal to that of the Left, but even carries off more than it, to make the right Side of the Body stronger than the Left, and arises from the very same Place where the *Aorta* sends out the Carotids. The left Subclavian is lower and narrower; and enters the Arm with a greater Obliquity than the other: The subclavian Arteries having passed under the clavicular Bones, whence they derive their Name, and arrived at the Arm-pits, are called Axillary; which, at the top of the Shoulder, are divided into two; one of which Branches seems to terminate at the Elbow, and the other frames the humeral Artery, which, at the lower Arm, divides into two, about the Cubit; the external called the radial, and the internal the ulnary Arteries; out of the last of which proceeds the *Mediana*, which is spent on the Muscles of the Arm. The radial Artery sends a Twig, or Branch, to the Root of the Thumb, and also to the fore Finger; and the ulnary Artery supplies the rest of the Fingers with two Twigs, one on each side: And the reason why they proceed from this last Artery rather than the other, is, because it lies more direct to the Current of the Blood's Motion; Nature always going



the nearest way to work, when it answers as well. But besides these distinct Vessels or Branches, there are several lateral ones, that serve all the Muscles by the way, and are too minute and obscure to deserve Names; besides, they are so numerous, and various, in distinct Bodies, that no distinct Idea can be framed of them.

The Arteries of the Trunk.

Thus far of the superior Extremities: next of the Trunk of the Body. Before the Subclavian divides itself at the Shoulder it sends off the Mammary Arteries, which are met by the Epigastricks, and have wonderful intercourse with them by their *Anastomoses*: Whence it proceeds, that upon the Rupture of the *Menstrua*, the Breasts swell, and are in great Pain in some Constitutions; and after they are vented, the Breasts fall again, and the Veins appear empty. The superior intercostal Arteries arise from the lower side of the Subclavian, which run along the Interstices of the four uppermost Ribs; and, together with the Mammary, serve the whole superior Part of the Trunk of the Body with Blood Vessels. Next to these are the Cervical, which arise likewise from the Subclavian, and passing upwards, and growing less, send small Branches to the vertebral Muscles and the Muscles of the Neck; and then enters the Skull, through the Holes of the transverse Processes, and meeting with the

Carotid

Carotid in the Brain, frame, together with them, the *Rete Mirabile*, sending off Twigs, by the way, to the *Cerebellum*, spinal Marrow, and these Parts.

The Carotid Arteries spring from the *Aorta*, at its upper Surface, where it curves, and what is strange, they proceed from it not both alike, the left one arising out of the *Aorta*, distinctly by itself, near the Subclavian; whereas, on the right side, the Carotid arises; not out of the *Aorta* directly, as the other does, but out of the Subclavian itself: The Reason of which is no small thing, as will appear, if we examine it: Had the right Subclavian and Carotid Arteries, each of them, arose distinctly from the *Aorta*, as the left do, then the Quantities of Blood, passing through them both, would not have been equal, in equal times; for by reason of the left Carotid, and subclavian Arteries lying in the Plain of the Blood's Direction, more would have passed through them, in any given time, than through those on the right side; wherefore Nature hath provided two Orifices for them in the *Aorta*, on the left side, and but one on the right; so that the Friction the Blood suffers, by passing the two Orifices on the left side, which it does not against one only on the other, makes the Quantity of Blood that runs through both, to be equal to each other in

The Carotid Arteries.

equal times : To illustrate which the better, it is like unto a current of Water running through two small Arches or Bows of a Bridge, and alike Current through only one broad, whose Bow, or Arch, is equal in width to both the other ; now the Water or Stream, that passes the first, will run slower, by reason of the greater Friction it suffers, than that which was through the second, in as much as the Surface taken off the two lesser Arches, are equal to the single Surface of the larger one ; and thus we see that the Resistance which the two Orifices of the Subclavian and Carotid make on the left side, that lie so near the Blood's direct Current, makes it the same in effect, as if they were as far distant from it as the other on the right side : Thus, what Advantage one hath in the high Situation, the other has in mechanical Structure ; the Diameter of the one Orifice on the right side, being equal to both them on the left ; whereby they are fitted to carry equal Quantities of Blood in equal Times. These Carotids ascend upwards, giving Branches in their Passage to the *Larynx*, Tongue, and neighbouring Parts, and then divide into two main Branches, the external, and internal : the first, with its subdividing Branches, supplies Arteries for the Face, Cheeks and Ears, and forms that which is felt on the Temples, and is often opened in obdurate

Pains



Pains of the Head. The internal Branch, which is largest, as having most part of the Head to serve, furnishes the inner part of the Jaw and Nose, and every single Tooth; and from thence the inner part of the Cranium, Meninges, and Brain; where it forms the *Rete Mirabile*.

The descending *Aorta*, is the lower part of that Curve which passes down on the left side of the Spine, and adheres to the Gullet; whence sudden drinking of cold Liquors in Summer, when a Person is very hot, causes Inflammations and Pleurifies. Before it arrives at the *Diaphragma*, it sends out of its hinder part, on both sides, the lower Intercostals, which run along the Sulci of those Ribs, which the superior did not serve; and also Branches to the Muscles of the *Vertebrae*, and Membranes of the spinal Marrow. Next to these are the Phrenick Arteries at the Midriff, which gives Branches to the *Diaphragma*, *Mediastinum*, and *Pericardium*. Then the *Aorta*, having penetrated the *Diaphragma*, it sends off the Coeliac Artery from before, because, were they all to perforate the main Vessel in one line, they would necessarily weaken its Walls, as, we see, many Windows do those of a House; therefore the Coeliac proceeds from the Body of the *Aorta* before, at the first *Vetebra* of the Loins, which, passing along under

The descending  
*Aorta*.

the Liver, is divided into remarkable Branches ; the right one of which, and the smallest frames the Gastrick, Epiplois, and the Intestinal ; and the left-hand Branch proceeds above the *Pancreas* or Sweetbread to the Spleen, and is there called the Splenick Artery, which is pretty large, and somewhat tumified ; and sends off, by the way, several small ones, which are named in Anatomical Authors. This *Cœliac* is a very remarkable Branch, as serving almost all the lower Viscera with Vessels, viz. The Stomach, the Spleen, the Cawl, the *Pancreas*, the Intestines, and Gall-Bladder, &c.

The Mesenterick.

Next to the former, is the Mesenterick Superior, which arises from the *Aorta*, on its fore part ; it serves the Mesentery and Intestines with Arteries, which are exceeding full of lateral Branches and Communications, more than other Arteries ; the reason of which is, because, considering their great Use, and tender Substance, they are liable to be greatly pressed upon, wherefore these Anastomoses are many here, that the Blood may easily pass off in one place, when obstructed in another, or otherwise a total Obstruction would often be caused, and a Gangrene unavoidably ensue.

The Lumbal.

The next are the Lumbal Arteries, the left of which are higher than the right, which,

which, as some say, is, because the Liver might press upon it: And it may be also to prevent the weakening of the *Aorta*, in that part, and consequently the Force and Current of the Blood, were they to arise on each side of the main Channel, directly opposite to each other: They serve the Muscles of the Loins and *Peritonæum* with Arteries; and even the spinal Marrow.

These follow the Emulgents; which are <sup>The Emulgents, &c.</sup> large, and two in number, on purpose to carry a great deal of Blood to the Kidneys, that a greater Quantity of Serum may be separated from it. The left is higher than the right, for a reason given above. Under these arise the Mesenterick Inferior, which serves the *Intestinum Rectum*. The Spermatick Arteries arise next, near the Emulgents, both proceeding from contiguous Beginnings, that they may receive the Blood slowly, and pass a long way before they penetrate the *Abdomen*, that by the slow motion of the Blood, the seminal Particles may attract one another, in order to the better forming a Consistence fit for such a thick Secretion; for which reason it is, that they arise with such small Orifices, and dilate as they pass downwards.

By this time the *Aorta* hath got to the <sup>The Ili-</sup> fifth *Vertebra* of the Loins, where it divides <sup>acks.</sup> into two Branches, called the *Iliacks*; at the Division of which springs a small Twig,



Twig, called the *Arteria Sacra*, at the lower part of the *Os Sacrum*. The *Iliacs* having passed but a little way, divide again into exterior and interior; from the last of which proceed the Hypogastricks, and Arteries for the circumjacent Muscles, and likewise the Umbelical. From the external arise the Epigastricks, which communicate with the Mammary, and *Arteria pudenda externa*, as the Hypogastricks afford Arteries for the nervous Bodies of the *Penis*, *Uterus*, and *Vagina*; from whence proceeds the matter of their Purgations. These *Iliacs*, passing to the Thighs, are called *Crurals*; which send some Branches above, and others below the Ham.

The *Sural*  
Arteries.

Below the Ham the *Sural* proceeds from it, and divides into three Branches, which serve the Muscles, the main Branch passing to the Foot, and there is divided again, and distributed amongst the Toes, just after the same manner, as the ulnary Arteries were amongst the Fingers. Thus we have run over all the remarkable Arteries, and may suppose the rest like unto them, only so small as to be imperceptible; of the use of which we have said enough already; therefore move now to the next Consideration, the continuation of these, namely, the Veins.

## C H A P. IV.

## Of the V E I N S.

**I**N the preceding Chapter we have run <sup>Veins, what</sup> over all the remarkable Divisions or <sup>they are,</sup> Branches of the *Aorta*, and considered <sup>and whence</sup> them as so many hydraulick Tubes, or hollow Cylinders of different Bores and Diameters according to the Parts they serve : We shall now observe here, that there is not one of those most minute Branches, but what hath a venal Branch adapted to it, which carries that Blood back to the Heart again, which its respective Artery brought from thence ; so that the Veins are no more than a continuation of those evenescant Arteries reflected back again to the Heart, thereby making one continued Channel, only inverted, so that by uniting their Tubes, they dilate more and more as they pass forwards, till at the last, they constitute the *Vena Cava*. The Veins are like unto the Arteries in their Shape and Substance, only weaker ; for they consist of three Coats or Membranes, like the other, but not so strong, because that they would rather retard the Blood's Motion through them, by reason of the great Resistance they would make against the Pulsation of the Arteries. But their Coats are lax and wider

wider than those of the Arteries, the better to receive the propelled Blood into them; for those that know but little of hydrostatick Laws, must own that a fluid protruded with the same Strength, runs slower through narrow than wider Canals, by reason of the great Friction it suffers in the first Sort; from whence it is, that the Blood moves much slower in the capillary Arteries than in those that are larger; therefore it is necessary the Veins should be thin and pliable: To make amends for the inconvenience that might follow from this laxity of the Veins, as nothing singly in Nature can be perfect, there are several Valves here and there, at the properest Places, to assist the Blood forwards in its Motion, where the Heart has the least power of influence upon it; sometimes one in a Place, sometimes two or three, as the peculiar Circumstances of that Part require; all which serve for great and many Uses, the want of which being no less inconvenient and dangerous towards the Ruin of the whole Oeconomy, than of a much greater or more noble Part. Their Number is almost infinite, the most conspicuous being reckoned a hundred and eight, but that there are many more is reasonable, in respect of their Use, to believe. They serve to prevent the Blood's passing back in the same Channel, and that it may not by its



its Gravity press upon the Blood *à tergo* or behind it, thereby to retardate its Motion ; they serve likewise to strengthen the sides of the Veins, that by their pliancy they may not relax overmuch, when Blood abounds in them ; and lastly, they serve to carry on Circulation ; for as the Veins are so long and distant from the Heart, without them it would follow, that the Blood would be very irregular in Quantity, some containing more and some less, and consequently the Motion and Distribution of the Blood through them would be greatly disordered. These Valves are most plentiful in all those Veins which are perpendicular to the Horizon, excepting those of the *Uterus* and *Porta*, because in them there is a periodical Evacuation from the first ; and slowness of the Blood's Motion is necessary in the second : Therefore Valves there would be very inconvenient. As to the Number of Veins, they are more than those of the Arteries, to make amends for the Thinness of their Coats, which are no thicker than those of the capillary Arteries. For were the Number of Veins to be equal to the Number of the Arteries entirely, the Blood would rush upon them with too much violence ; wherefore, as it is, there is no Pulse to be felt in them, except in very brisk Fevers indeed ; because the Blood passes through them with a continued Stream,

Stream, and moves from a narrow Channel to a wider; which alone is enough to take that Motion from it, which experimentally may be proved. The Veins, I say, exceed the Number of the Arteries, on purpose to give the freer Passage to the recurrent Blood, which without this Provision, would be too quick in its Motion for the Weakness of the venal Membranes, and would also relax them too much, or else would crowd them to that degree as to hinder its own Motion, just as too many People flocking out of a Door at once, instead of making good Speed, hinder one another and obstruct their Passage. And thus we see Provision is made for every minute Circumstance, and a Guard for every Danger; for what one is deficient in, another Mechanism amends; wherein the Laxness, Width, Number, and the Valves of the Veins are accounted for; and though they seem to carry in them something contradictory to one another, yet the Composition and due Situation jointly concur for the great Service of Circulation. Thus much of the Veins in General; we now pass to Particulars.

The Veins  
particularly  
considered.

Here we must observe, That the particular Branches of the Veins are much like those of the Arteries, excepting the Differences. I have mentioned above; for the *Cava* descending answers the *Aorta* descending,

ing, and so of the superior Ones; and those Veins which have peculiar Names, different from their respective Arteries, are These. The *Vena Cava* before it enters the Heart hath one Branch, which comes from the superior Part of the Body, called *Cava descendens*, (note, that I trace them from their Trunk, as I did the Arteries, to be more intelligible,) and another that comes from the inferior Part called *Cava ascendens*. The first bring all the Blood back from the former, as the second does from the latter. Those Veins that enter the first are these; the coronary Veins, which have Valves to prevent the return of Blood out of the hollow Vein into them. The next is the *Azygos* or *Vena sine pari*; as soon as it pierces the *Pericardium*; which enters the *Cava* on the hinder and right side; it is single in Men, having no fellow on the opposite Side; whence it takes its Name: It is made by the Union of the Veins of the Intercoastal Arteries, on each Side, which passing along the right Side of the *Vertebra* of the *Thorax*, enters the *Cava*, as we said, on the Right-Hand; though in Sheep and other Animals it hath been observed to enter it on the Left. Sometimes a Branch from the sinister Emulgent, and sometimes from the *Cava* ascending, enters this Vein, thereby accelerating the Blood that passes through it, and lessening the Weight of so much



much Blood in the ascending Trunk of the *Vena Cava*. The true use of the *Vena sine pari* is, to convey all the Blood of the Muscles of the Back and *Thorax* into the descending *Cava* a little above the Heart, by that Means to lessen the Quantity and consequently the tardity of the Blood's Motion, that passes up the ascending Trunk thereof; whence it is plain, that more Blood comes into the Heart, by the *Cava* descending, than passes out by the *Aorta* ascending; for was all the Blood that passes out of the *Aorta* descending to return to the Heart, by one single Trunk, the great Weight of it, would resist and greatly oppose all the Force of the Heart, and consequently hinder its ascent; wherefore Nature hath made this Provision for the contrary. And thus the Motion of the Blood is exactly regulated in the Veins and Arteries, for the due assisting and promoting of it in the one, and moderating of it in the other: More of which see in what Mr. *Cowper* hath delivered to the *Royal Society*.

Vid. Philosophical  
Transact.  
No. 280.

Next unto this Vein is the Intercoastal Superior, which comes from the Interstices of the four first Ribs, where the other does not reach. Then it enters the Pulmonick Vein, so small as not to be easily found; it is the Vein of the Bronchial Artery of Mr. *Ruyfck*. By this Time the *Cava* divides

into

into two Branches called the subclavian Veins, which receive the mammary from the Breasts; the Cervicals send some muscular Ones. Then passing to the Arm, they are called Axillary, which again being divided into two, the superior Branch is called the *Cephalick*, and the inferior the *Basilick*; the subclavian Vein also, the internal and external Jugulars, which proceed from all the internal and external Parts of the Head, Face and Brain, as the Carotids were there before divided; for a more exact Description of which I refer to those Anatomists that have fully treated of them, avoiding too much prolixity here, or transcribing more than the Subject requires for our present Purpose.

The ascending Trunk of the *Vena Cava*, comes from the inferior Part of the Body, and does not lye upon the *Vertebra* of the Back, but runs at a small Distance from them, to prevent the Resistance thereof to the Blood's Motion, by rubbing against it, which would happen, were it placed close to it. At the Midriff it receives into it the Phrenic Vein, and, directly under the *Diaphragma*, many small ones from the Liver; then the *Adipous* or Fat-Vein from the Membranes and Fat of the Kidneys. Next are the Emulgents, one on each Side, which have each a Valve at their Orifice, to prevent the Blood flow-

The Branches that enter the ascending *Cava*.

The Sper-  
maticks.

ing into them, as it passes up the *Vena Cava*. Under these it receives the Spermaticks, the right one entering the higher Part of the Trunk of the *Cava* itself, and the left, the Middle of the left Emulgent, to regulate the Motion of the Blood up the *Cava*, as I have said before, to prevent weakening of it by too many Perforations, and burthening it with too much Blood, where it is weakest. But Nature varies very much in the Insertion of these Veins, since sometimes both of them enter the *Cava*, and sometimes both the Emulgents; and sometimes again, though seldom, both the Emulgent and *Cava* with a forked Insertion.

The lum-  
bal Veins,  
etc.

Next to these are the lumbal Veins, which enter the *Cava* behind, because the former were inserted before, there often is but one Vein of this Kind, when it suits best with the Mechanism of the Body. A little below this, the greatest Artery or *Aorta* passes above the *Cava*, and as it were crosses it, and then the *Cava* divides into two Branches, called the *Iliac*. The Reason why the *Aorta* crosses the *Cava* is plain, viz. to forward and promote the Motion of the Blood in both: In the *Cava* by beating on, and the *Aorta*, by removing the pressure it would suffer by the *Cava* before, and the Spine behind; whereas as the *Cava* hath Valves, and the Course of its Blood is contrary to that of the *Aorta*, it assists it up-  
wards,



wards, which would occasion an inconvenience on the other Hand. At this Division of the *Iliacks*, it receives the *Vena Sacra*. Then the *Iliac* Veins divide into two more, the external and internal, as we said of their Arteries. The External receive into them, the Epigastrick, the *Vena Pudenda*, and some remarkable ones from the circumjacent Muscles. The Internal receive the Hypogastricks, which constitute the *Hemorrhoid* Veins externally, and those that come from the Bladder, *Matrix* and *Vagina*. The external *Iliac*-Vein having received all the former, makes the *Crural*, which receives several Branches more, namely the *Saphena*, which passes down the inside of the Thigh and Leg, and receives Branches from the great Toe. This is usually opened in Distempers of the Womb, and is very safe, there being no Artery or Nerve very near it. The rest of the small Veins are those that come from the Muscles, and enter this, together with the *Suralis* and *Poplitea*, which form those *Plexus*'s of Veins, so conspicuous on the upper Part of the Foot.

As to all the rest of the Veins, they take their Names from their own Arteries, and therefore need not be repeated again, only one Thing we shall observe here more, namely, that we see that there are but few Veins that enter the Trunk of the *Cava*,

The *Vena Sacra* and *Iliacks*.

The *Crural* Vein, &c.

The *Vena Porta*, its Mechanism and Use.

in respect of the Number of Arteries that pass out of *Aorta* or Trunk of the main Artery; which when we have considered, it will manifest as great a design in Nature, and the wonderful Mechanism of the Parts, as any we have yet touch'd on; for hereby not only the Blood in the *Cava* is less, where it is weakest, but another necessary Effect is nicely produced; that is, by the *Vena Porta*. This Vein is made on purpose for the Liver, and enters it on its hollow or concave Part, between the two Protuberances called *Portæ* or Gates, with a broad but short Trunk, seated under the *Duodenum*; it arises from the Intestines, Mesentery, Spleen and *Omentum*, and most of those Parts, with small Beginnings, which joining together as they pass forwards, at last constitute this one Trunk of the *Vena Portarum*. From a mistaken Notion of this Mechanism, that Opinion of the Antients arose, that the Chyle passed through these to the Liver, sending off by the Way, the more feculent Part of it to the Spleen, there to be concocted into an acid Juice for the stimulation of Hunger, which, when too austere, they thought was the Cause of Agues: But from the Mist of those Errors, Dr. *Harvey* hath happily set us free and clear. This Vein enters the Liver, and there divides again into innumerable small Branches, which answer to, and End in

the proper Veins of the Liver, which carry the Blood back again into the *Cava*, there being a Branch of one, wherever there is a Branch of the other. The use of the *It's Use.*

*Vena Porta* is to serve the Liver as an Artery, which would have brought the Blood too hot, violently and rarified for its Use; whereas this Vein collects that Blood, that hath lost much of its Motion, from those Parts we have mentioned, and brings it slowly here to form Bile out of it, which is a thick Liquor, and requires the Blood to be in such a State for its Secretion. So that, as we said before, we see, the Veins and Arteries are but one continued Channel, from and to the Heart, only divided into many lesser Ones, for the great service of Secretion; which is the next thing observable.

But before we proceed to that, we shall add a few things more concerning the quantity of the Blood, the force of the Heart, and the velocity of its Fluid. As to the first, it is by the Learned computed to be about twenty Pounds or twenty-five at the most, two Ounces of which are propelled every Sistole of the Heart, which Pulse is repeated four thousand times in one Hour; therefore there passes through the Heart, every hour, in a large strong Body, eight thousand Ounces of Blood, or, which is all one, the Quantity of five hundred

Of the  
quantity of  
the Blood,  
the force of  
the Heart  
and the Ve-  
locity of it's  
Fluid.



Pounds in the same Time: This being allowed, it follows, that a quantity of Blood, equal to the whole Mass, passes through the Heart, twenty times an Hour, which is at the Rate of once every three Minutes. I am sensible this will hardly gain Credit with some; but if we allow two Ounces, or half a Quartern of Blood to be contained in the left Ventricle of the Heart, it will necessarily follow as we have said. But even granting that the Heart does throw out but one Ounce only at a time, and the Pulse beats four thousand times in an Hour, at that Rate two hundred and fifty Pounds will pass through the Heart in an Hour's time, which will make a Quantity equal to the whole Mass, pass through it, ten times in an Hour, or once in six Minutes; and so proportionably to the different Temperament, Sexes and Ages. But if this also be thought too quick, we will suppose a Man has but sixteen Pounds of Blood, and only one Ounce is propelled out of the Ventricle of the Heart at a time, which is the least that any grown Person can be supposed to have, this undergoing four thousand Pulses in one Hour, makes four thousand Ounces to pass through the Heart in the said time; and the whole Quantity being sixteen Pounds, or two hundred and fifty-six Ounces, at that proportion, a Quantity of Blood equal to the whole

whole Mass, will circulate or pass through the Heart about fifteen times an Hour, or much about once in four Minutes: So that, at the very least Calculation, the Circulation of the Blood is very rapid. But as Circumstances are not alike in all, nor always the same in one Body, so these Proportions vary, according to these various Causes, whence no certain Determination can be given of this Matter; though enough may be learned, from what we may attain to, to instruct us in this Knowledge of the Blood's quick Motion: But supposing this Account not exactly true, yet it is not very far from it. Hence we may account for the long and lingring Deaths of some Bodies, even when past the Assistance of the best Means; for the Circulation of the Blood being so quick, if the mortal Obstruction be not in a principal Part, or very extensive, the Patient may linger many Days on his sick Bed, before he departs, though in the mean while, beyond all the Power of Art or Medicine to restore him.

The Quantity of Blood then being given, and the Number of Pulses in a determinate time, it follows next to add, the Force or Strength of the Heart's Motion on the Blood and other Juices of the Body. This hath employed many great Men to find out, amongst which the famous *Borellus* hath endeavoured to shew, its Force, to move twenty

Of the  
great force  
of the  
Heart's  
Motion.

Pound of Blood, to be equal to the pressure of one hundred and eighty thousand Pound Weight; which is far wide of the Truth, and occasioned by his not considering the Blood, as already in Motion, but at Rest; for it requires, as every one knows, but a small Strength or Power to continue a Body in Motion, to what it does to set it in Motion at the first. There-

Vid. Keill's  
148.

fore we are the more obliged to Dr. Keill for his Calculation; in the Consideration of which, these following Particulars are to be observed. First, we must have the Velocity wherewith a Fluid flows out at any Orifice without Resistance, and then it will be easy to determine the Force which produced that Motion. Now the Velocity with which a Fluid flows out of any Orifice uniformly without Resistance from an interior Fluid, is equal to the Velocity of a Body which descends a Space of the same Length with that of a Cylinder, whose Basis is equal to the Orifice, and whose Magnitude is equal to the Quantity of the Fluid, that flows out in the same Time; but as the Blood flowing out of the Heart is much resisted, both by the interior in the Arteries and Veins, and by the Resistance of the Vessels themselves it passes thro', it cannot move the Blood with all that force it otherwise would, were there no such Impediments; much of its strength being spent,



spent, in overcoming all those Resistances: If then we could know the Quantity of this Resistance, or how much the Velocity of the Blood is diminished by it, we might easily know the absolute Force of the Heart. To this purpose the Doctor opened the Iliack Artery and Vein of a Dog, and found, that the full Force of the Heart's Motion, and Velocity of the Blood in the Artery, when cut, is to that Velocity when not cut, which is the Velocity of it resisted, as  $7\frac{1}{2}$  to 3; wherefore, if the Heart throws out two Ounces every Pulsation, then the Blood must move through the *Aorta*, at the rate of 156 Feet in a Minute; therefore the absolute Velocity, wherewith the Blood would be forced into the *Aorta*, did it meet with no Resistance, would make it fly 390 feet in a Minute, or about 6 in a Second. But as the Sum of the Sections of the Branches of the *Aorta*, is greater than that of the Trunk, the Velocity of the Blood does constantly decrease, as they branch from one another; whence it follows, that the greatest Velocity of the Blood, in the former, will be, to the least in the latter, as 5283 to 1; and as it still moves slower in the Veins, than in the Evanescent Arteries, these being to them, as 324 to 441, it follows, that the Blood moves slower 7116 in the Veins, than it does in the *Aorta*; for it is a certain Rule, that the further the  
Blood

Blood moves from the Heart, the slower is it's Motion, and the slower its return; wherefore there can be no time when it can be said, that the whole Mass hath directly circulated through the Heart, in any given time; the times being directly as the Spaces the Blood runs over, before it returns to the Heart, and reciprocally as the Velocities: Whence some part of the Blood may pass through the Heart, some hundreds of times for some other parts once.

Thus we see, the Heart is employed, in continuing the Blood in its Motion; but how it came by it first, is without the Power of Mechanicks to account for; for certain it is, were all things relating to it, in the like State, at the first, as they stand in now; that is, had the Resistance of the Blood bore always the same proportion to the Heart's Force, that it does now, the Heart could never be able to set it in Motion, the Power of it not being so great as was formerly thought; the whole Force of the Heart, according to some, not exceeding five or eight Ounces. Whence it is plain, that if Circulation was once stoped, all the Force of the Heart could never be able to set it a moving again. But whilst there remains a pretty near Ballance, between the Force of the Heart, and the Resistance it meets with, all is well; but when either exceeds too much, nothing less than

the utter Destruction of the whole Machine would ensue; for by the Velocity of the Blood, continually increasing, in the first Case, all things would be shaken to pieces by the Rapidity of its Motion, and, like a Mill too hard strained, must, of necessity, have a Tooth or Screw, or some principal part tore from it, to the universal Damage of the whole Engine. On the other hand, when the Resistance encreases alone, more than what its Force can dispense with, the Motion of the Blood continually decreases, till at the last it stops, and is Death itself, and nothing less.

Thus far we have proceeded to shew the Vessels serving to Circulation and Sanguification, ending at the Heart, where we first began: We now pursue those Vessels of the Body, which succeed next; which are, in general, the Subject of the next Chapter.





## C H A P. V.

*Of the SECRETORY DUCTS.*

The *Secretory Ducts*,  
their Na-  
ture, Ori-  
gin, and  
Use.

**H**AVING, in the preceding Chapter, fully treated of all the remarkable Vessels of Sanguification, it follows next in order, to examine those of Secretion; and to shew their Origin, Mechanism, and Use. And here we enter a large Field of Contemplation, the true Knowledge of which, will alone give us a direct and full Idea of the whole Animal Body. Intricate indeed it is, they being so various and many in Number, the whole Machine being little else than a Congeries of them; in describing of which, I shall, according to our wonted Method, first give a general Description of those small Canals, called *Secretory Ducts*, and then treat of each particular kind by themselves.

The *Secretory Ducts*,  
what.

As to the First, we are to know, that all these *Secretory Ducts*, are so many Divisions and Continuations of the foresaid Arteries, a little before they become Veins, and differ nothing in Substance nor Shape from them, only in the smallness of their Orifices and Diameters, by which they are adapted for their Service, their Mouths being too small to admit the red Globes of the Blood into them (except in Inflammations).

tions). They differ likewise from the Veins, in the place and manner of their Origins, the Veins being a continuation of the Capillary Arteries, in a streight Direction, parallel to their Axis; but the *Secretory Ducts*, in a Direction perpendicular to them: For they arise out of the very sides of the Evanescient Arteries, at their Extremities, and so are a continuation of the same, as was said before.

As to their Number, they are infinite; Their Number inconceivable. for many arise from one single Artery, and there can be no distinct part separated from the Body, that abounds not with many Arteries, though ever so small. What a vast Number then must there be, that arise from all the Arteries of the Body taken together? They even exceed our Idea of them, and there is no point belonging to us, that is not sufficiently stocked with them; all the Solids of the Body, excepting the former, and the Bones being nothing else, but heaps of such Canals. It is these alone that compose those many Glands, that are every where dispersed over the Body; it is these that separate the several Juices of the Blood; it is these that are the Seat of most Diseases we are subject to; and it is to the good Constitution, and free Secretion of these, that we are obliged to for a comfortable and healthy Life, whilst we continue in these Bodies:

In

In short, they are the most numerous and wonderful parts of all the Solids, and perform most useful Service, in separating all the several Juices from the Blood, for all the several Uses of Life.

Wherein  
the *Secre-*  
*tory Ducts*  
differ from  
one ano-  
ther.

Having shewn how they differ from the Veins, we shall next shew, how they differ from one another. And this they do not so much, by their different Egrefs from the Arteries, as in their different Diameters and Distances from the Heart, whereby they are fitted to separate different Fluids, of distinct Consistencies; whence it is very observable, that those *Secretory Ducts*, that have the largest Diameters, are, for this purpose, placed the furthest from the Heart, that the largest Particles may, by their slow Motion in the small Arteries, have the more Time and Opportunity to attract one another, and so become fit to pass off at those Ducts, and *vice versa*. Those Glands that separate the minutest Fluids, are planted nighest the Heart, on purpose to receive their Fluid, hot and rarified, whilst the Blood is in the best Disposition to part with them; that is, when the Blood-Globules are very small, and need not so much *Serum* to swim in.

These said *Secretory Ducts*, after they leave the Arteries, which they arise from, wind and turn about with each other, arising from the same Artery, this way, and

that



that way; length ways, and cross ways; and in all manner of Directions; and so form those round Bodies, or Knots, called Glands; and such Glands, or Kernels, as separate a thick Juice, have their Ducts so much the longer, and more contorted; for a purpose we shall shew presently. These Ducts, or Secretory Pipes, that thus arise from around all the utmost Extremities of the evanescent Arteries, do, in their Progress, form their respective Arteries, unite, and, as if it were, run into one another, thereby enlarging their Diameters, till, at the last, they constitute but one Pipe, or Canal, amongst them, which is called the *Excretory Duct*, which serves to carry off that Liquor, which the former Ducts secreted from the Blood, and, like so many common Canals, or Sinks, convey it to its proper Receptacle; the Particulars of which, we shall shew hereafter.

But, besides these two sorts of Vessels, *Secretory*, and *Excretory*, there are another <sup>The Lym-</sup> intermediate sort, called *Lymphaticks*, <sup>phaticks.</sup> which arise not from the Blood-Vessels immediately, as was formerly thought, before the Animal Structure was so well known, but from the *Secretory Ducts*, just as they arose from the Arteries, at Right Angles, and serve for a more peculiar and necessary Use; namely, to carry the thinner part of those Juices, the *Secretory*

cretory ones had separated from the Blood; for as they suffer a thick Liquor to pass through them, a thin one would necessarily pass too along with the other; but as the thin Liquor is not necessary for use, where the thick is, but rather useless and inconvenient in those Parts; therefore, these Lymphatick Vessels are ready, on all sides of these *Secretory Ducts*, to convey off, and transport so much of the thinner Fluid, or *Serum*, as may leave the other in its proper Consistence and Thickness as it ought to be in; I say, these Lymphæducts separate the thinner and more useless parts, from that compound Fluid, which the *Secretory Duct* had secreted from the Blood, leaving it thicker or thinner, according to the greater or less Number of those Lymphatick Vessels that arise from them, and, in their Passage, enter one another, and form, at last, large Tubes, or Canals, as we said of the Secretory Vessels, till, at the last, they empty themselves in the Blood-Vessels, as of no further use. Hence we plainly know the Reason, why those Glands, that secrete the thickest Fluid, abound most with Lymphaticks; as for Instance, the Liver, the Testicles, and the like; which, by the by, renders them subject, so much, to be the Seat of Dropsies; whereas the Kidneys, Brain, and such like Glands, which secrete the thinnest Fluid, have

have but few or none of them. And thus we see, that all Glands consist of three sorts of Vessels, of the first, second, and third Order; namely, Secretory, Lymphatick, and Excretory Ducts; all which, as we have shewn, are the very Production and Continuation of the *Aorta* and its Branches, under the Power and Influence of the Heart, from whence they all derive their Origin.

The Glands then, are those Parts of our Bodies, which separate all the several Juices, as so many Strainers, from the general Mass of Blood; and are, in themselves, nothing else but a Congeries of Blood-Vessels, or a Continuation and Circumvolution of very small Arteries, which send from all Sides, small lateral Branches, called *Secretory Ducts*, which send off other smaller ones from them, called *Lymphæducts*; then, by uniting as they pass along, they constitute every Gland, and one common Tube, or Passage, called an Excretory Duct: This, I say, is the general Mechanism of all the Glands of the Body, and are pretty near alike, as to their Substance, Course, or Texture, but yet separate different Liquors, according to their Shortness and Situation, some few Circumstances hereafter to be considered.

The  
Glands,  
what.

Their  
wonderful  
Mecha-  
nism.

And here we may, with Pleasure and Amazement, behold the wonderful Provi-  
G dence



dence of Nature, in the most curious Mechanism of the Glands; where, though Nature, who loves Symplicity in all her Operations, hath composed so many and various sorts of them, yet keeps to a general Rule in them all, as far as the Case will admit of; for as the *Secretory Ducts*, that constitute every single Gland, at last, joyn all in one Excretory Duct, so do the Lymphaticks; those of the superior part of the Body, entering the Blood-Vessels to dilute it, and serve again for the like Use, and those of the inferior parts enter the lacteal Vessels, and the Receptacle of the Chyle, to dilute it, and to keep them moist and full, when there is no Chyle in them, thereby preventing any casual Obstruction, that at any time might happen. The *Secretory Ducts* of the Glands, have likewise, generally, a Cistern, or Receptacle, into which they deposite their Liquor; as the Bladder for the Ureters, the Intestines for the Bile, and the seminal Bladders, for their different Vessels, and so of the rest. But the Excretory Ducts of the cuticular Glands, deposite their Liquor in no particular Receptacle, but on the Surface of the Body, by Transpiration, Perspiration, or Sweat, as being altogether useless to Nature.

Thus much I think may be sufficient to give an Idea, of the *Secretory Ducts*, and

the Composition of the Glands in general; whence we may safely conclude, that a Gland is only a complicated Artery (over whose external Coat, as in all Arteries and Veins, are Branches of Nerves, to serve their Spiral Contortion) which sends Secretory Vessels out of its sides, after which it degenerates into a Vein. These *Secretory Ducts*, *Helvetius* terms, for method's

*Vid. Helvetius, his Animal OEconomy.*

sake, Lymphatick Arteries, and those which carry the *Lympha* back again to the sanguinary Veins, he calls Lymphatick Veins; which indeed may, to some, give a clearer Idea of them, than the general manner of describing them can do. Hence I might proceed to the Description of every particular kind of Gland; but as that would anticipate our Design, I shall leave this, as an Introduction for every one, and proceed to one thing observable more.

Which is,

Lastly, To account for the Secretions of those different Juices as our next Design, and somewhat difficult to do, it having employed many learned Men to little purpose, till the happy Dawn of mechanical Reasoning, hath ushered in some greater Certainty in this Affair; upon which Foundation we shall offer what follows. And here let those Men, who do so much decry the Use of Mathematical Reasoning, as applied to human Bodies, behold how

*Secretion, the manner how performed*

far we are, in this case, obliged to it for this Knowledge, and what mean Notions the Antients had about Secretion; and what wretched ones of the Mechanism of the Glands, taking them to be no more than spongy Substances, like so many Sieves to strain the Juices through.

The whole  
Body vas-  
cular.

But we now know all the Body to be vascular; and therefore Glands are but the Continuation and Convolution of the same, only very small; and from their different Diameters and Distances from the Heart, the right Idea, and the true Notion of Secretion may easily be conceived.

The Noti-  
ons of the  
Antients  
erroneous.

Others again, thought the Glands were so many Cisterns, that contained a certain Liquor, which the Blood, by Fermentation, threw off upon them; that it might be conveyed from the common Mass. But this likewise is false, there being no such Ferment in the Blood, as they suppose; neither do the different Liquors secreted, proceed from the different Figures of the secreting Orifices of the Glands, admitting only Particles of singular Figures to pass through them, as some Moderns have fancied. For, as I said before, all the Vessels, from the largest to the smallest, are conical, or cylindrical, and consequently there can be no difference in the Figures of their Orifices.

Moreover, in Hydrostaticks it is well known, that Fluids press equally on all sides



sides; therefore the sides of the Vessels of the Body, being soft and pliable, must be equally distended thereby; that is, in other Words, a Section perpendicular to the Axis of the Vessel must be a Circle; consequently then, I say, the *Secretory Ducts* must all be cylindrical or conical; the last of which they are.

We see then, that all these Hypotheses will no ways serve to solve, this so notable a Phenomenon; namely, how Glands separate Fluids from the Blood, and how different ones secrete different parts there-

How the Glands separate Fluids, considered.

from. To sum up all then in a few Words, we shall lay down these few Principles; from whence we can at once deduce, a very short, but clear Description of them all, without tedious Prolixity. First, the different Diameters of the Orifices of the *Secretory Ducts*. Secondly, the different Angles they make with the Trunk of their Arteries. Thirdly, the different Velocities with which the Blood arrives at their Orifices. These three fundamental Propositions, are sufficient to account for all Animal Secretions, more of which may be seen, most elegantly set forth, in

Dr. Wainwright's Two and Twenty Propositions, which would be too long

Vid. Wainwright's Non Naturals.

here to insert. Therefore it follows, from the preceding Rules, that, to secrete a thin Liquor, the glandular Ducts

must be of the smallest Diameters ; of great Contortions ; and the Blood's Celerity must be reciprocally as the Viscidity, of the Liquor to be separated, requires. And what other Deductions may follow are so very plain, that I leave them to the Reader to make, as he thinks fit.

Mutual Attraction of the Parts of Matter.

But besides what hath been laid down ; Constitutions of the Solids, and different Velocity of the Blood in different parts of the Body, there remains one Circumstance more to let you into the entire Theory of Secretion ; and that is, a mutual Attraction of the Particles of Matter of the like Form ; which, though it be equally diffused through the Mass of Blood, yet according to the different Densities of Particles, and their Figures, some will be sooner united, whilst others will require a much longer time to be joined together ; and some will, according to the largeness of their Surfaces, in proportion to their Solidities, have a greater Tendency to unite, and cohere more firmly, when joined, than others. Some, from this Theory of Attraction alone, have pretended to account for the manner of Secretion, but will no ways answer ; for the other Circumstances, already mentioned, must have a chief Share herein ; both to separate from the Blood, and to carry off the thinner part of that which is separated, the better to

put the designed Matter separated, in a fit Condition, to modify itself into its proper Consistence by Attraction.

If, together with the particular Mechanism of the *Secretory Ducts*, you will allow this Law of Attraction in the Fluid itself, you will then easily comprehend, how all the several Juices can be formed, or made out of the Blood, which did not before pre-exist in it, in that Form they appear under now: For the common Mass, that circulates in the Veins and Arteries, consists but of a few Principles, as every one knows; therefore, for the Formation of so many different Fluids, as are daily secreted from it, we can impute it to no other

How different Fluids are separated.

Cause, than the various Combinations, Attractions, and Modifications they undergo, when separated in their proper Glands; and therefore the Glands are situated in different parts of the Body, at different Distances from the Heart, as the particular Combination of the Blood is necessary and fit, in such a Place, to form the Humours proper to pass through such and such a Gland: As for Instance, in those parts of the Body, where the parts of the Blood are most dissolved, there, and in that part will be placed such Glands only, as shall separate Humours, that consists of the most simple Combinations; and on the contrary, the contrary Design: So that a small Variation



of these forementioned Circumstances will be sufficient to vary the Liquor separated, when we have the Number, according to Dr. Keill, of thirty-seven different sort of Humours, that are secreted by different sorts of Glands. Wherefore it need be no wonder, that we see so many new Juices produced, which by no Art could ever have been, or can be, extracted from the Blood itself, as there is contained in the Sanguinary Vessels.

What the  
Glands  
consist of.

To return to the Glands, we find, by this time, they are the small Evanescent Arteries, convoluted with Lateral Branches proceeding from them, called *Secretory Ducts*; with other lateral Ones proceeding from them, called by *Helvetius* Lymphatick Veins; both of which, in time, form, of all the simple Branches, one single Tube for themselves, which have the Name of *Excretory Ducts*. Now the best resemblance of this Mechanism of Glands, that I can think of, is this of a small Wier, which take, and twist and turn it, one half in all manner of Directions, over and a-cross at oblique Angles; then, to this clue of Wier, tie, at certain Distances from one another, small pieces of Thread, which, at their other extremity, fasten together with a Knot; then to these Threads, tie others, at certain Distances, as before, of another Colour, at the same place with  
the

the first, and then, at their Extremities, fasten them all together with a Knot, and you have the Draught of the Mechanism of a Gland before your Eyes at once: The one half of the Wier being streight, answers to the Artery; the other half contorted, answers, or resembles, the Circumvolutions of the said Artery at its extremity: The first set of Threads tied to the said clue of Wier, represents the *Secretory Ducts*, proceeding from the Arteries; and the second Order of Threads from the first, and of another Colour and smaller, show you how the Lymphaticks arise out of the *Secretory Ducts*; and the Knots at both their Extremities, resemble both those sort of Vessels, ending in their *Secretory Ducts*: Only *Secretory Ducts*, as we said before, have more or fewer of Lymphatick ones, as their Diameters are wider or narrower; that is, *Secretory Ducts, more or fewer, why.* as their Liquors that enter them, are more or less abounding with Serous parts. For where parts of Matter of a larger size can enter their Orifices, those of a lesser certainly must; but as the lesser cannot be hindered entering, they may be extracted again. Wherefore, the *Secretory Ducts* must have Lymphatick ones proceeding from them, to carry off the superfluous Serum, to leave the other in a right state of Modification. From whence we also see the Reason, why the globular or red parts of

of the Blood, cannot enter the *Secretory Ducts*, because the Section of their Diameters, exceeds that of the Orifices of the Glands; therefore it passes by, and returns back by the Vein, unless in Inflammations, where the *Secretory Ducts* are over-extended, and then some of the globular parts of the Blood, enter with great Heat and Pain.

*Lymphatics, what, and by whom discovered.*

Lastly, the Lymphatick Vessels, being those Parts, which I shall have no occasion to speak of, after this Chapter, I shall here say something more particular of them. They are very fine thin Tubes, which arise from some sort of Glands, containing a thin clear, transparent Liquor, which they convey thence to the chyliferous Vessels, and Veins, discovered, if not mistaken, by *Bartoline* and *Rudbeck*, in the Year 1651. By reason of their great tenderneſs, and the motion of the *Lympha* being very slow, which is due to their remoteneſs from the Heart, they are well furnished with many Valves, as we ſaid of the Veins, having one at every Inch diſtance from one another. As they all ariſe from the Glands, ſo they paſs along towards the Veins, where they empty themſelves upwards; and into the Chyle-Veſſels and Receptacle, thoſe which are in the inferior part of the Body: Whence Buboës ſo quickly proceed from ſoul Embraces, by reaſon of the Lymphæducts that run along the *Penis* and paſs to the Groins.

The



The Rupture of these in the *Abdomen*, is the true Cause of that Dropsy, called an *Ascites*.

Having spoke thus much of the Glands in general, or of the second, third and fourth sort of Vessels, it would follow next to trace them singly, and handle each glandular part by it self, as the Brain, Liver, *Pancreas*, and the rest of them. But as they are all remarkable for their largeness and use, I shall class them in particular Chapters by themselves, and therein show the Likeness or Analogy, they all bear to each other.

We shall begin then next with the Bowels of Digestion and Chylification, and see how far they carry any likeness to these of Circulation; and though they are generally the first parts treated of in Authors, I thought proper to begin with the Heart, as being the *Primum Mobile*, and chief Actor, from whence the rest of the Fluids have their Motion and Vessels; by which Method, I think, we shall beget much quicker and clearer Ideas, of the wonderful Structure of an Animal Machine.

## C H A P.

## C H A P. VI.

*Of the* STOMACH.

The Intro-  
duction  
to the *Vis-  
cera.*

**T**HE Vessels of Sanguification and Secretion have been our Subject hitherto, in the three preceding Chapters; where we considered them as proceeding from their Basis the Heart; and traced them so far as to become invisible and almost inconceivable; therefore we must now supply that defect by Reason, and draw Inferences from the former Premises, where our Eyes can lead us no further, by allowing, that all and each of the Parts of the Body are vascular, that is, are made up of those said Vessels, as well the exterior as the interior Parts of it, to wit, the Skin, the Muscles, the Membranes, and even all the *Viscera* contained within the three Venters; and then we shall soon gain a plain and easy Idea of the whole Animal Oeconomy, as it were in one View. But then, says one, from whence arises the vast Differences of the Parts, and which, we see, perform such opposite Offices, and bearing little or no Resemblance to one another? This Difference proceeds from the various Numbers, Situations and Magnitudes of the Fibres of those Parts: Which always is sufficient to account for all those Differences that occur: For

Instance,

Instance, we see, that some parts of the Body have many and strong Fibres, and others but few and weak ones, and but slightly interwoven; some parts have them running in one Direction, and some in another; some have these constituting Fibres of large Diameters, whilst other parts have them very fine and narrow; and thus, from these and such like Circumstances, all the many differences of parts naturally proceed. But what is the Cause of all this? <sup>Whence the difference of the Parts.</sup> Ask the curious and inquisitive Persons. The Cause then is, from the first Stamen or Delineation of the Parts, when first formed by God in *Adam*, and the continuing Cause is the force of the Heart, and different velocity of the Blood, wherewith it arrives at these different parts of the Body, beating in, as it were, those nutritious Atoms, as so many Wedges, between the Interstices and Vacuities of the Fibres; thereby pressing them closer, and making them so much the stronger, as they have the greater quantity of Matter compressed in little and smaller Bounds; thence the Brain, Eyes and Testicles are the finest Parts of the Body, and have their Nerves the least guarded; I mean, the two latter; which are therefore most acute in Feeling, and soft in Texture.

Thus much as Introductory to our Description of the *Viscera*; which we consider,



sider, as so many Apendages of the Heart and its Vessels deposited or placed at certain Distances from it, to separate and prepare such Liquors as are necessary for the Service of the whole Body, to keep up and continue the Motion of the Heart, from whom it receives its own; so making a *perpetuum Mobile* within us till Death put a stop to it.

The Stomach, its Texture, Situation and Use.

We begin then next with the Vessels of Digestion and Chylification: And first of the Stomach. The Stomach, as every one knows is a large hollow Bowel, made up of many Fibres of various Directions and Strengths serving to receive, embrace and retain the masticated Food, to be farther prepared and comminuted, in order to yield a most fine Tincture, fit to pass the lacteal Vessels, for recruiting what was lost, and for the Nourishment of the whole Body. It is usually situated in the lower Venter, for the Assistance of the Motion of the *Diaphragm* and Muscles of the Belly, and of the Intestines surrounding it, to keep it in more warmth and to assist it in its Office. The Substance of the Stomach is also threefold. Its external Coat it hath in common from the *Peritonæum*, pretty thick and strong. The second is Muscular, consisting, somewhat like the Heart, of strong Fibres of various Directions, which, by their joint Actions, draw the sides of the Stomach and

its two Extremities towards its middle, thereby making an equal Contraction and Pressure for the expulsion of its Contents, when it is to be extruded. The first Order of these muscular Fibres are streight, and extended upon the upper part of the Stomach, and in their Action render it shorter. The second Order are Circular, and compass it round, cutting or intersecting the former at right Angles, and in their Action brace it to it. The third sort are oblique, surrounding the left Orifice of the Stomach, called the *Cardiac*, and serve to draw the right Orifice towards it, whereby they also constrict the last, and dilate the former; so that no Aliment can find any passage through the *Pylorus*, when all these Fibres are together contracted. The best Cuts of which may be seen excellently well done, in Dr. *Willis's* Works. The third Membrane or Coat is Nervous, and thin, and therefore exquisite in Feeling, which it is necessary it should be, to throw out any hurtful Body that by chance might be taken inwardly, before it goes further into the Body to do more Mischief. This Membrane is much larger than the rest, being full of Plaits and Wrinkles, the better to retain and comminute the Food, that it may not directly slip out of it. To these some add or reckon a fourth Coat, consisting of short Fibres, standing perpendicular

*Vid. Willis  
De Medicamentum  
Operationibus. P. 15.*

cular on the last Coat, which forms that downy or velvet-like Surface on the inside of the Stomach; but I rather take this lining to be no distinct one of itself, but to proceed from the Orifices or Extremities of the *Excretory Ducts* of the Glands, that are plentiful in the nervous Coat of the Stomach, which stand up in a great Number, and are designed for great Use, to defend the nervous Membrane under them, from irritation every Minute by sharp Liquors or solid Bodies; and likewise to retard and detain the useful Slime or *Mucus*, from passing away too soon, along with the Aliments, out of the Stomach; and somewhat to assist the Stomach to restore itself to its usual Bounds, by their natural Elasticity, they being very short and thick, when that is much distended; the Reason of which, I think, every one knows.

Its Blood-  
Vessels.

The Stomach, as was said before, receives Arteries from the *Cæliac*, and sends remarkable Veins to the *Porta*, viz. the *Gastrick*, the right and left *Gastroepiplois* and *Pyloric* Branch; besides another called the *Vas breve*, which enters the splenic Branch, immediately under the Coat of the Ventricle, derived from the *Peritonæum*.

Its Nerves.

Its Nerves it hath from the eighth Pair or *Par Vagum*, each of which, dividing into two Branches, the exterior and interior, form,



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The Use and proper Action of the Stomach is Digestion; which is no more than a comminution or separation of the Parts of the Aliment, into such fine Particles as are fit to enter the Lacteal Vessels, and to circulate along with the Mass of Blood; so that it is a kind of natural Putrefaction, whereby the Cohesion of all the little *Molecule*, of which our Food is composed, are broken and dissolved. And this is brought about not by one single Cause alone, but by several concurring together; as first by the Fluids moistening the Aliments, after the Teeth have done their Part, the Power of which, to divide asunder the solid Parts of the Fluid, is evident in a Rope with a large Weight at one end, and fixed to a Point by the other, and Water applied to the

H

Rope

Rope with a Sponge, which will make it even raise a most considerable Resistance, for the Particles of Water entering the Pores of the Rope, like so many Wedges, which will encrease its Thickness, and consequently shorten its Length; and so the Weight must be elevated; and this said force is greatly encreased by the *Impetus* it receives from the heat of the Stomach. To these Causes we must add, the Motion of the Stomach itself, which is computed to amount to many Pounds weight; and likewise the Action of the *Diaphragma*, and the Muscles of the Belly, which contribute no small matter towards this division of Parts of the Food in the Ventricle. But beyond all the rarefaction of the Air, contained amongst the Particles of the Aliments, and what is wrought into them by Mastication, is the chief Cause, together with the heat of the Stomach, of Concoction; which can easily dissolve and comminute the Mass, in fine small Parts, fit to make that Tincture which we call Chyle. But more of this, where we treat of Fluids proper to the Stomach, in our second Part.

Hunger,  
what, and  
how caused.

But here we must not pass by a notable *Phænomenon* belonging to this Part, and more particularly to the Solids, namely, Hunger; by which we are acquainted with the need we stand in of more Food and Refreshment, without which

which warning and timely notice we should be often endangered by our own Negligence. What Hunger is in effect, there are none but can give an account of it; namely, a desire of Food; but what causes that Desire, hath been variously disputed amongst the Philosophers, till the new Method of enquiring into such Subjects hath opened a Door to Knowledge, that lay always hid before, for want of taking a right Method of discovering it; for some of the Antients, thought it proceeded from acid Juices in the empty Stomach; and some from an attraction or sucking of the empty Parts; and some again from a Fermentation occasioned by the Spittle or *Saliva*, together with some Salt or indigested Acids adhering to the Coats of the Stomach, when empty; all which, together with *Paracelsus* and *Helmont's Archæus* are utterly false and erroneous.

Hunger then is a painful Sensation on the Nervous Coat of the Stomach, exciting in the Mind a desire of Food, caused by the mutual Friction of its two sides one against the other (like the two Stones of a grinding Mill) which when unguarded by Aliments, misaffect the Nervous Coat; for which reason the Stomach is better stocked with them than most Parts of the body, on purpose for this Intention. And

*Hunger, a grating of the sides of the Stomach one against another.*



that this is the true Cause of Hunger is confirmed by several Proofs; for *Saliva*, that is depraved by Salivation, Scorbutick Cafes and the like, spoils the Appetite, by prolonging Digestion, and by weakening and relaxing the Elastick Tone of the Fibres of the Stomach; besides the great quantity of Slur and viscid Matter, that, in such Cafes, clog its inner Surface, and take off the force of Friction.

How eating suddenly refreshes.

Again, a further Proof of this Hypothesis we have from fasting too long, where, at last, that Hunger which before was so urging, shall, if not relaxed with Food, go quite off; which may easily be accounted for by this Theory; which is after this manner. The Stomach having continued its peristaltick Motion a long time, the Spirits are at the last exhausted, whence it must suffer a Relaxation, the Nerves being not turgid enough with Spirits, as before; wherefore this grating Motion must of necessity cease for a while, and the Appetite thus go off; and as one Cause depends on another, we may here perceive the Reason of the so sudden Refreshment, that follows the taking of Food, when one is exceedingly an hungered, when, as it is utterly impossible, for any part of it, how far soever, to have entered the Blood in so short a time, so as to have caused the

sudden

sudden and so remarkable Refreshment, and Alteration; and therefore it must proceed from the sudden removal of the former Pain, and the pleasant Sensation it raises on the Nervous Coat of the Stomach, which causes a general Laxity of the whole Nervous System, and a fine gentle Ovation of the Nervous Fluid, which is Pleasure it self; as we shall shew when we come to speak of that Fluid.

This also brings us to a better understanding of the Reason, why Food being taken, when one hath over fasted, it will cause, especially in weak Persons, sudden Faintings; which is thus. The Stomach having ground it self tired, that is, consumed the Spirits faster, than the Glands of the Brain answering to those Nerves, namely the eighth Pair, can supply it, of necessity it relaxes greatly, and Hunger goes off; but upon sudden eating the Refreshment is so great, that the Ovation of the Spirits is so strong, as to cut off their necessary Supply to the Heart, which hath its Nerves from the same Pair; and therefore its Motion remits; the Pulse becomes weak; the blood moves not by Pulses, as before, but only by its own Motion; therefore the nervous Liquor is not produced from the Brain; wherefore its Motion almost stops, and fainting directly ensues: All which Symptoms continue, till enough of nervous Li-

Why fainting follows sudden Refreshment.

quor is afresh secreted, to fill the eighth Pair of Nerves, to set the Heart and Stomach in their usual Motion again. Hence likewise, we see the Cause of Faintings in some People after Bleeding, upon sudden News, too much Laughter, long tickling and the like, which would be too long here to mention; therefore I refer them to the Fluids.

Canine  
Hunger,  
how cured.

In Fevers likewise, from the same Laxity of the Stomach it is, that they want an Appetite; and for this Reason also, that all bitter and vitriolick Medicines will restore it when lost; which can no ways be applicable to the Ferment of the *Saliva*, but this Theory laid down; and even in the Disease called the *Canine Hunger*, where Oyl is serviceable, it is not by blunting those supposed Acids, which are thought by some to be the Cause of Hunger, so much as by relaxing the too rigid Fibres of the Stomach, and by smoothing and lubricating the Surface of the inner nervous Membrane, thereby taking off much of the Friction of its Sides, against each other. Several more such like Arguments I could bring, but have a natural Aversion to tediousness upon this Occasion, so shall not be troublesome to my self or to the Reader.



Here I might proceed to account for the sudden Merriment and Refreshmentt that attends drinking of a Cup of good Liquor, as they call it; likewise for the Nature and Manner of the Signature, or marking of the *Fetus* in the Womb of the Mother, and the Causes of a *Pica*, called *Longings*; and also, of depraved Appetites in Children, and Maids in the Green-Sickness: But as all these, with many more such *Phænomena*, belong properly to the nervous Fluid, I shall fully treat of them in my Book of Fluids, and conclude this Head, with one Observation more, to wit, of the strange things that have been found to grow in the Stomach; as Stones, Worms, and even larger Animals. Of the first of which, *Bauschius* gives several Instances, *viz.* of Stones breeding in the Stomach. And there was a Patient in St. *Thomas's* Hospital, if I am rightly informed, who vomited up a live Animal, that had lived there some time, of the bigness of ones little Finger, of a very strange and odd Figure, so that they did not know what Species to reckon it of; and this happened a little before I was acquainted there, so that I had not the good luck to see it my self, but received it by the Information of creditable Persons. This puts me in mind of what Mr. *Coats*, Surgeon in

*Vid. Bauschius Ephemerid. Med. Phys. Tom. 2. Obs. 181.*

*Richmond* in *Yorkshire*, told me, when fellow Pupil, at the said Hospital, of a Patient of his Masters, who had, of her own accord, taken some live *Millepides*, or Chefs Buggs, into her Stomach, for some Disorder, as is usual amongst the Vulgar to do; and he affirmed to me for Truth, that one day, as she vomited, they came out of her Stomach alive, and crawled about the Room, though she had taken them many days before; and not only those, that she had swallowed, came up again, but many more, which had bred by the heat and moisture of her Stomach; and this he saw with his Eyes, and affirms it to be true, being a discreet Gentleman, and worthy to be believed.

To conclude then, we see, that this is the chief Bowel, or Machine of Digestion, as the Heart is of Circulation, and that it is the Origin of the Intestines, or they a continuation of it, as the Blood-Vessels are of the Heart; for, in every thing, they are alike, only the Stomach is larger and thicker, by reason of its powerful Office of Concoction, though not performed alone, or chiefly by its Attrition, as Dr. *Pitcairn* seems to say, nor by Fermentation, but by the Expansion and Rarefaction of the Air, which, by its Elasticity, tears asunder the cohering Particles of the Food,

Food, thereby resolving them into fine Mummy: The Power of which Air, thus rarified, is evident from *Papin's Engine*, whereby hard dry Bones can be reduced into a soft downy Substance, only by putting them into a dry Pot, close shut, and placed in boiling Water. We proceed to what becomes of it next, and view the further Analogy, that is between these Vessels and the former.





## C H A P. VII.

## Of the I N T E S T I N E S.

Of the In-  
testines,  
and their  
Division.

**T**HE Guts are a continuation of the Gullet and Stomach, making one large Canal from the *Pylorus* to the *Anus*, consisting of three Coats, like the other: The external is common, the middle muscular, and the inner nervous. They are generally divided, for distinction sake, into small Intestines, and great ones; and three of each: The small ones are, the *Duodenum*, the *Jejunum*, and the *Ileum*: The first begins at the turning of the *Pylorus*, and, passing behind the Stomach, is free from the Mesentery, and hath two Ducts entering it, at its lower end; the one from the Liver and Gall Bladder, called *Ductus communis cholidochus*, and the other from the *Pancreas*, or Sweet-Bread, called, from the first Discovery of it, *Ductus Wirtzungii*: It takes its Name from its Length, being twelve Fingers breadth long; it is streighter, and hath its Coats thicker than the other Guts, to moderate the Motion of the Aliments, as they pass through it.

The Second is called *Jejunum*, or hungry one, because it abounds most with Lacteal Vessels. It makes many Windings from

from the right side to the left, and back again, filling all the upper part of the umbelical Region, and is almost twelve Hands breadth long, very much like unto the third Gut, called *Ilium*, only the Folds of its Coats are in greater Number, and nearer one another than those of the *Ilium*.

The third is the *Ilium*, almost as long again as the former, and hath its Name from the place it is situated in, *viz.* within the Cavity of the *Ossa Ilii*, and fills all the lower part of the umbelical Region, with many Windings and Turnings, as the former did the superior part thereof. Its Passage is a little narrower, and its Coats thinner than those of the *Fejunum*, still with a Design of retarding the Motion of the Aliments, to have all the Chyle separated, that can be useful, before they descend to the second Order of Guts, where they are turned into Fæces. It is this Intestine that falls down in Ruptures, and is the Seat of the Iliac Passion, which is occasioned by one part of it, entering the Cavity of the part immediately above or below it, like the turning in of the Finger of a Glove, whereby the Passage of the Contents are obstructed, and Death, (if timely Remedy does not take place) consequently follows.

The three thick Guts are the *Cacum*, *Colon*, and *Rectum*. The first is about four

A Description of the thick Guts, and their Mechanism.

four Fingers breadth long; it is called so, because not passable at the other end; so that the Excrements come in, and go out at the same Orifice. Its other Extremity is not fastened to the Mesentery, but to the right Kidney, by means of the *Peritonæum*; whence it may be worth while, as the use of it is not as yet rightly found out, to enquire whether it hath any Communication, by any small Tube, with the Ureters, to convey any serous Liquor, when one drinks too plentifully. Some indeed think, that this Gut serves as a second Stomach, where the Food undergoes a further Digestion, to part with more Chyle, through the Lacteals below it; whilst others again, think it to be a Store-House, for the Excrements of the Foetus before Birth, to be retained in till after it is born; and bring this Reason, because it is always much larger in them than in adult Persons, in proportion to the different Bigness of their Bodies; and because, in grown Persons, it is found altogether empty, but in the Foetus full of Excrement. However the Case is, this I think is plain, that it was of more use formerly than it is now, but as it is a part of the Body, it must remain, though there is an end of the use it was made of. But what the direct use of it was in the Foetus, is hard to say, though I can hardly believe it, to answer



as a Store-house for the Excrements of the Child, there being no more Excrements than what might be contained easily in the Guts, without such a small Assistance; besides the Child's Food being of so fine and fluid a Nature, as not to yield much Fœces to be contained therein.

Well then, since none of the former seem to be in the right, I shall even venture to offer my slender Opinion about it, not so much affirming it to be certainly true, as to excite others, to enquire more minutely into, or concerning it; for to one that loves Knowledge, the lack of a single Particular, is a great Breach, not to be put up with, if the Knowledge of it is any ways to be attained. I think then, that it may serve as a *Diverticulum* for the Liquor Chyle, that the Foetus receives in by the Mouth, as it swims in the Fluid contained in the Amnion Membrane, to streighten the Passage into the *Colon*, and to support a Column of Chyle in the small Gut, to enter the Lacteal Vessels, the quicker and easier; the Child, in that State, not having the Advantages of the Air, the Motion of the *Diaphragma*, and the abdominal Muscles, and but a small peristaltick Motion of the Guts themselves, to forward this Motion of the Chyle into the Lacteals; therefore I say this Gut is placed here, between the thin and thick  
ones,

A Suppo-  
sition con-  
cerning the  
use of the  
*Cæcum*.

ones, exactly, at both their Extremities, to retard the Motion of the Chyle in the Foetus downwards, and to retain it the longer in the small ones, for the foresaid purpose; and that this is so, seems to have some further Confirmation, from the Continuation of the Gut *Ilium*, to the beginning of the *Colon* at Right Angles; whence likewise may be the Reason, why the Foetus is never subject to a *Diarrhæa* before Birth; but this I only suppose, humbly submitting to better Judgment: More of which hereafter.

The *Colon*,  
its Mechanism and  
Course.

The *Colon* is the second thick Gut, and the largest and the widest of any; near half as long as the *Ilium*, being about nine hands breadth, it beginning where the *Ilium* ends: From thence it ascends by the right Kidney, to which affixed, it passes under the Liver, from thence, under the bottom of the Stomach, to the Spleen on the left side, to which it is also fastened; then it passes to the left Kidney, and terminates at the upper part of the *Os Sacrum* in the *Rectum*. Now the Reason of this long winding Course is, to retain the Fæces, that one might not always have occasion to exonerate; also to assist Digestion, in some Measure, by the heat of it, about the bottom of the Stomach; and likewise, that the Excrements might be the more powerfully pressed upon

by

by the Actions of the abdominal Muscles, and that they may be more easily rowled down by their own Weight, and so be quickly expelled.

At the beginning of this Gut there is a <sup>A Valve.</sup> Valve, formed by the Production of the innermost Coat of the Intestine. It prevents the return of the Fœces upwards, and likewise assists a little, together with the former Causes concurring, to prevent the fine Chyle of the Fœtus, from slipping down hither, before it becomes solid enough. It hath also a strong Ligament, about the breadth of a middle Finger, running along its upper side from the *Ilium* to the *Rectum*, which nicely serves to strengthen it, against the great Weight and Load of the Excrements, and to draw it together into Cells, the better to retain and retard its Contents from flowing out too speedily. And hence it is, that Fomentations with Clysters, relieve Patients of several Maladies, in those surrounding Parts.

The third and last thick Gut is the *Rectum*, which, descending in a streight Line in the *Pelvis* or the Hollow of the Hips, ends in the *Anus*. It is about one Hands breadth and a half long. Its Coats are thicker than the former, because the Basis of all the rest. It begins at the upper Part of the *Os Sacrum*, and going streight down is

The third  
and last  
thick Gut  
described.



is tyed to the Extremity of the *Coccyx*, by the *Peritoneum* behind, and in Men to the Neck of the Bladder before ; whence comes the Sympathy between these Parts. It hath much Fat about its external Side, instead of the Cawl, which does not reach so far down. The utmost Extremity of this Gut forms the *Anus*, which is kept close shut by the Sphincter Muscle, and suspended by two pair of others, which, when they act, draw the *Anus* upwards ; a Relaxation of the inner Membrane of which Gut, is called *Proidentia Ani*, which is relieved by Astringents.

Their  
Blood Vessels.

They have all Arteries, as we said before, from the superior and inferior Mesenterick and Coeliac Arteries ; and their Veins constitute the right and left Meseraick, and enter the *Vena Porta*.

Glands and  
Use.

All the Intestines abound with Glands on the inside, which filtrate a proper Liquor to lubricate their Cavities, and moisten the Excrements ; wherefore they are larger and more numerous at the Extremities of the thin Guts, than near the Stomach, where there is not so great need for them, but only in the thick ones, where the Fœces are dry, and require moist: From all which, together with the Liver, flows all the Matter evacuated in Purgings.

And thus we see, to carry our Analogy along with us, that the three superior Guts

that

that come immediately from the Stomach; answer to the *Aorta*; and the three inferior ones to the *Vena Cava*. The Lacteals arising from the first, resembling the *Secretory Ducts* of the Arteries; for they really are the *Secretory Ducts* of the Intestines, which separate a fine Tincture from the Aliments taken in by the Mouth, just as they do, certain Fluids from the heterogeneous mixture of the Blood. So that we may well conclude with Dr. *Cheyne's* Fourth Proposition, that the Intestines are really a Gland, and the most visible one in the Body; whose *Secretory Ducts* are the Lacteal Vessels, and whose common Conservatory, or *Pelvis*, is the Receptacle of Chyle.



## C H A P. VIII.

## Of the L A C T E A L S.

The *milky*  
*Vessels*,  
when, and  
by whom  
discovered.

THE next kind of Vessels that belong to the digestive Province, are the Lacteal, or milky ones, which are the *Secretory Ducts* of the Intestines, which serve to carry the Chyle to the Blood, for the Nourishment of the Body. They were first discovered by *Casper Assellius*, Anatomist at *Padua*, in the Year 1622, who named them *milky Veins*. They all arise from the Intestines, but most of them from the *Jejunum*; they are very numerous, and thin transparent Vessels, their Orifices, lying hid, under the downy Substance, or Surface of the Intestines, are smaller than their Diameters a little further in, on purpose to prevent crude Matter entering them, whereby they might become liable to frequent Obstructions. They are so small as not to be seen by the best Microscope, and necessary it is, that they should be so, or else any one knows, what would be the ill Consequence, if they were not. They pass with an oblique Course, first from the Guts, and then proceed forwards to the Glands in the Mesentery, where, uniting in their Passage, and

forming



forming larger Branches, which are called the Lacteals of the first Order, they discharge their Liquor into the vascular Cells of the Glands, dispersed up and down the Mesentery, from which Glands arise again other Lacteals of larger Size, which carry the Chyle immediately into the Receptacle; these are called the Lacteals of the Second Order.

The Receptacle is a little Bag, made, The Receptacle, its Place and Description. or composed of the Expansion of the former; it lies between the descending Trunk of the great Artery, and the *Vertebra* of the Loins, and is biggest between the *Cæliac* and emulgent Arteries, surrounded with several vesicular Glands, which empty their Lymph into it. It holds about an Ounce, or an Ounce and a half, at one time in it, and was first found out by *John Pecquet*, a Physician of *Paris*, in the Year 1651. It receives all the Chyle from the Lacteals of the Second Order, and sends it up the Thoracic Duct, to enter the subclavian Vein.

These Vessels have many Valves, which Their Valves. admit the Entrance of the Chyle from the Guts, and hinder its Return; where- by its Motion forwards is not a little assisted by the bye. They are never quite empty, for when there is no Chyle in them, they are full of Lymph, which

always passes through them to dilute the Chyle, and also to moisten and keep open the Lacteals, when there is no Chyle in them, that their sides may not furr, or adhere to one another. They rise likewise from the Guts, with their Mouths obliquely upwards, for the easier Entrance of the Chyle into them, and for which reason, the inner Coat of the Intestines is longer and looser than the rest, forming, in the small Guts, large Segments of Circles, by which, with the peristaltick Motion of the Guts, the Motion of the Stomach, the Midriff, and Muscles of the Belly in Respiration, together with other like Causes, the Chyle is protruded into the minute Orifices of the Lacteals, where, meeting with the Lymph continually flowing, and the Motion of the Mesentery, it is driven forwards to the Glands, which, by their cellular Texture, still adds somewhat to its Motion, till it arrives at the Receptacle, where it is still acted upon by the force of the Aorta, emulgent Arteries, and other neighbouring Parts, which force it gradually to mount the thoracic Duct, which is about the bigness of a Goose-quill, and divided, in human Bodies, by reason of their erect Posture, into two or three Branches; thereby taking off some

its Gravity, which unite again into one, and creeping along the Gullet, whence it receives fresh Impulse, it marches to the left subclavian Vein for Security, where it opens at one or two Orifices, which are covered with semicircular Valves, like so many Trap-Doors, that the Blood may slide over them, and the Chyle slide in under them.

This Duct hath likewise several Valves, The Mechanism of the Thoracic Duct. at several Distances, which keep up the Chyle, and hinders that which hath once passed them, from falling back again.

It runs up the left side, on purpose for the Assistance it receives there, from the Pulsation of the great Artery, which it could not enjoy on the other. It enters the subclavian Vein more especially, because least subject to Chances, and because nearer the Heart and Lungs, where it is to be further prepared. This

Duct likewise receives several Lymphæducts from the Parts around it, whereby we may see, that the lymphatick Vessels, Vid. Pacquet's Anatomical Dissertation on the Motion of Chyle. p. 145. are no insignificant Parts of the Animal. Those that would see more of the Causes of the Chyle's Motion, may consult *Pacquet*, where they are fully treated of.

Thus far we have run over the most remarkable Particulars belonging to the Lacteal Vessels, and traced the Chyle



into the sanguinary Vessels; and there let us leave it, till we come to treat of the Substance of this Fluid, and here view again the Analogy between these Vessels of Digestion, and those of Sanguification; for as I said before, the Stomach is here as the Heart; the Intestines as the Arteries; and the Lacteals as the Secretory Ducts; with their Lymphatics coming into them, instead of going out of them; only with these Differences, that they are wider and coarser than the other, and the *Secretory Ducts* of the Guts are but of one sort, as they all make but one Gland; whereas those of the other are of many Kinds. To carry the Comparison a little further, we see, I say, they have their Lymphatics, and the Receptacle of the Chyle is their Cistern, for the *Excretory Ducts* to empty themselves into; and last of all the Thoracic Duct is the common Tube from the said Cistern. Thus far having carried our comparison, and viewed the particular Vessels of the Heart and Stomach, with their likeness and uses, we proceed now to examine the other principal Part, the Brain, and there shew likewise, how far this Mechanism will consist with its Constitution; for from the Heart, Stomach, and Brain, proceed all the necessary Actions of Life and Motion.

tion, their Communion and Sympathy being so very strong and intimate, that they equally partake of each others Pain and Pleasures; and in short, are the three principal Wheels in the Animal OEconomy; and if but one be hurried or disturbed, the whole Fabrick will be disordered thereby.



## C H A P. IX.

## Of the B R A I N.

**T**H E Brain is the third principal Part, or Bowel of the Body ; the Fountain of all our Animal Spirits, without which we should be no better than Stocks ; and our fine Bodies without them, however nice and wonderful its Frame may be otherwise, would be quite motionless, and inserviceable to us ; for the Nerves are the immediate Organs of the Soul, whose Union with the Body is more remarkably manifest here, than in any other Part ; so that I cannot determine which of all these three, the Heart, the Stomach, or the Brain, hath the Precedence, except the Niceness and Intricacy of the Mechanism of their Parts, and then the last gains it.

Its Divisions.

Its Substance in general, is divided into two distinct Parts, or Portions, the *Cerebrum*, or *Cerebellum* ; and those again into two more, *viz.* the Cortical or Cineritious, and the Medullary or Nervous.

Of the *Cerebrum*.

The *Cerebrum* or Portion commonly meant, when we discourse of the Brain, is the largest of the two, and lies chiefly on the fore part of the Head ; the *Cerebellum* is smallest, and lies on the back part



part thereof. They are both equally enclosed within the *Dura* and *Pia* Membranes, which guard their fine and soft Substance from those Injuries, their tender texture Subjects them to.

The external or cortical part of the Brain is, says *Malpighius*, who was the Pope's Physician, nothing but a heap of little oval Glands, made of the Capillary Arteries that belong to it, which secrete the Animal Spirits or Nervous Juice, which come thither by the said Arteries. These Glands are the smallest in the Body, and for very good Reason, because the Fluid, by them secreted, is the very finest.

The cortical or glandular part of the Brain is divided into two Hemispheres, by a Process of the *Dura Mater*, called, the Falx, into the right and left Portion; the design of which is, to defend and secure the Brain from Concussions on every little Occasion, and to enlarge the Surface for a greater Number of Glands, to be placed on the inside of each Lobe, which otherwise could not have been, had the Brain been one continued Sphere. And for this Reason also it is, that the Brain hath so many Circumvolutions, resembling the windings of the small Guts. In the Middle of it is, the beginning of

The Use and great Contrivance of the cortical parts of the Brain.

of the medullary Substance, or of the Nerves, which are a heap of fine white Fibres that run in parallel Lines, and are no more than the *Secretory Ducts* of the foresaid Glandular Substance of the Brain, serving to convey the Animal Liquor to all the Nerves, to be distributed over the whole. And thus we see, the Brain is only a Glandular Substance, whose Mechanism is somewhat like unto the other *Viscera*, excepting some particular Circumstances, of its own, which we shall examine in what follows.

The Glands  
of the Brain,  
why of an  
oval Fi-  
gure.

The cineritious part of the Brain, I say, is but a cluster of very fine minute oval Glands; Oval, because that Figure contains most convolutions without pressing too much on one another; and small Diameters they are of, because the Liquor to be secreted, is of parts of the smallest Size, and they are many in Number, because of great Service to the Body, their Liquor being used and wasted by every Part, where a few could not supply the Body with Spirits enough to keep it long awake.

Each single Gland hath its own *Secretory Duct*; which it sends off on the inner side, which altogether constitute the fibrous or medullary Substance of the Brain, and which, passing along

out

out of the *Cranium*, forms the *Medulla Spinalis*, and all the Nerves of the Body, even to the very furthest Extremity of them. Whence we see, the same general Rule of Glands obtains here also by Nature, who affects simplicity in all her Operations, and never uses more ways to compass an Effect, when fewer will answer as well. As thus the Capillary Arteries that go to it, are wreathed backwards and forwards, in an Oblong, to constitute this oval Form.

They are all enclosed or guarded with the *Dura Mater* in general, which surrounds them like a Case; and with the *Pia Mater* in particular, which immediately covers the single Glands every where.

The Vessels of the Brain are Nerves, Arteries and Veins; of the first hereafter. The Arteries are, as was before said in their proper Chapter, the Carotid and the Cervical, which are wonderfully intermixed and distributed through all the Substance of the Brain, and circumjacent Parts: First with many turnings and windings on the *Pia Mater*, and at the last are lost in the little Glands of the cortical Substance of the Brain; which turnings are purposely contrived by Nature, to break the strong stream

The Blood  
Vessels of  
the Brain,  
the Contri-  
vance.



stream and swift current of the boiling Blood from rushing too violently into the tender texture of the Glands, and to give the rarified Blood sufficient time and opportunity to attract its more gross Particles, before they enter the fine Substance and Nervous Ducts of the Glands, where they would stop the Passage to the Nerves, and cause all or any of those most dismal Diseases the Brain can be incident to ; and therefore the Brain is placed at such a distance from the Heart, and likewise the Arteries greatly wreathed and winded upon the *Pia Mater*, before they enter. Wherefore nothing can pass into the Glands but what is exceeding fine, and smaller than the Diameters of the Ducts.

The Mechanism of the Veins.

The Veins of the Brain have likewise something in their Mechanism very extraordinary ; for they pass not through the *Cranium* at the same perforations or holes that the Arteries do, nor run along their Sides when entered, as they do through all the rest of the Body ; by reason in the first Case, that the Arteries, upon any great turgency of the Blood, would be apt to compress and squeeze them by their Pulsation against the bony sides of the Passage, and so cause an Obstruction of the Blood's Motion through them ; whence

a stagnation and an extravasation of it would certainly follow, to the ruin of the whole Machine; and for the same Reason the Veins arise from the extremity of the Arteries, and take another Course from them, proceeding streight to discharge themselves into the *Sinus's* of the *Dura Mater*, which are made on purpose to receive it freely, lest at any time it should become a burthen to the Brain; and from thence it passes down the Jugular Veins. Thus much of the Brain in general. Now let us view its Parts in particular, and see their wonderful Mechanism and Office in respect of one another.

Below the depth of all the Circumvo-  
 lutions of the Glandular Parts of the  
 Brain, the first thing that appears in the  
 Medullary Part, (for here lies the Va-  
 riety, the former being one uniform  
 Mass or Substance of Glands,) under  
 the Process of the *Dura Mater*, or the  
*Falx*, is the *Corpus Callosum*, to which  
 the under part of the former adheres,  
 formed by the close union of the me-  
 dullary Fibres on each side, which makes  
 it firmer than the rest, whence it takes  
 its Name. It serves for a covering to  
 the two Lateral Ventricles which lye  
 directly under it, and are commonly found  
 full

The De-  
 scription of  
 the Parts  
 of the  
 Brain.

full of Water, in those who die of Epileptick Fits.

The *Septum Lucidum*.

Next to the callous Body, and directly under it stands the *Septum Lucidum*, as a Partition to the said Ventricles, and is extended to the *Fornix*, which lyes in the Bottom of these Ventricles, and is thought only to be a Production of the *Pia Mater*, which lines the insides of those Ventricles. The *Fornix* seems to spring from the *Corpus Callosum* with a double Root, which, uniting at the other end, serves for a covering to the third Ventricle, which lies directly under it.

The Ventricles of the Brain, their Use.

Thus these three Ventricles are formed, but for what use is hard to say. And it would be worse than Idleness here to relate, the many frivolous and empty Opinions of Authors about them, as Store-Houses of the Animal Spirits; or for the purer parts of the Air to mix therewith, through the *Os Cribiforme*, both of which are known to be false and contrary to the frame of an Animal Body. Nor can I tell, whether the Modern Anatomists, ascribe to them a better Use, in making them Receptacles or Sinks for superfluous Lymph, and such like excrementitious Juices to be collected in, for a discharge by proper Passages, which indeed seems a lit-  
tle



the feasible, from the Position of the *Plexus Choroides*, which is made up of many small Arteries, Veins and little Glands, which reaches from one Lateral Ventricle to the other, and passes under the former, above the third Ventricle, and also hinges upon the *Glandula Pinealis*, and is woven about it like a Button: All which Circumstances do seemingly shew, that all those Glands of this *Plexus*, as the Pineal Gland, do separate a Lymph into these Cavities, which is carried off again by the Pituitary Gland, and not by the mammary Processes, and so through the *Os Cribriforme*, which are only for the Olfactory Nerves to pass through, and are by them so filled, that nothing else can pass that Way. If this be not the right Use, perhaps those hollow Places, were only design'd for a fence to the Parts contained in them; which by the tendernefs of their Substance, and the slow Motion of their Fluids, makes the least Pressure or Resistance extreamly hurtful to them.

In the Ventricles there are several Things worth taking notice of; two in each of them; the *Corpora Striata*, which are the very tips of the *Crura Medullæ Oblongatæ*; and if any part of the Brain, deserves to be the Seat of

Of the Parts  
contained  
within the  
Ventricles.

of the Soul, I think, they do; and the other two are the *Thalami nervorum Opticorum*, from whence the Optick Nerves have their Origin. The former of these have their internal Substance made up of fine white *Striae* and streaks perhaps of a double Direction; the Seat of the Memory.

The third  
Ventricle  
described.

Under these, covered by the *Fornix*, lies the third Ventricle; which is a little chinck formed by the *Crura Medullae Oblongatae*, where there is a hole that passes down to the Pituitary Gland, through the *Infundibulum* or Funnel, which lies directly under this small Passage, which is a small Conduit, made of the medullary Substance, covered, as all the parts are, with the *Pia Mater*, and pierces the *Dura Mater*, at the basis of the Skull, and sinks into the Substance of the Pituitary Gland, which is situated in the *Sella Turcica*, to convey into it, the Liquor that distils from the former Ventricles.

In the hinder part of this Ventricle there is also another small hole or perforation, called the *Anus*, which opens into the fourth Ventricle, which belongs to the *Cerebellum*, in the upper part of which lies the *Glandula Pinealis*, about the bigness of a Pea, supposed by the Antients to be the usual Seat

seat of the Soul, but in reality is of no more use than other Glands of the Body. It is fixed to the *Nates*, which lie under it, and by their Protuberances form that hole called the *Anus*; and behind there are two more prominences of the same Figure, but a little less, called the *Testes*; which difference, in respect of the Bigness, is more remarkable in Brutes than Men, and which are in Men much bigger, in Fools and Naturals, than in others, as Dr. *Willis* vid. Dr. Willis Cerebri Anat. Cap. 4. Tab. 4. observes, who gives an excellent Cut of them in his Anatomy of the Brain. They are all covered with a fine Net of blood Vessels, which shews them to be Lymphatick Glands, to purge the Animal Spirits of their more serous Parts, before they enter the Nerves. For which reason Calves, whose Spirits are very watry, and their texture soft, have them largest, whereas Lions and such hot Creatures, need them not so big. And what confirms this thing more still is, that Stones have been found herein, and the Animal Operations in the mean while never disturbed: As both *Sylvius* and *Reyner de Graeff* do write. But to proceed, the Passage or Conduit, which reaches from the *Anus* to the fourth Ventricle in the *Cerebellum*,



*bellum*, lies in that part of the *Medulla Oblongata*, which is betwixt the *Cerebrum* and the *Cerebellum*, called the *Isthmus*, the upper part of which is called *Valvula Major*: It is of a medullary Substance, and serves to keep the Lymph from falling out above the Nerves in the basis of the Skull. These being all the remarkable parts of the *Cerebrum*, we examine next those of the *Cerebellum*.

Of the *Cerebellum*,  
its texture  
and use.

This is not so big by far as the former, but consists of the like cortical and medullary Substances, only its superficies makes not those turnings and windings as the other; but its foldings are streight, and form large Segments of Circles, like edges of Plates laid one upon another, which are largest in the middle, where the Substance of the *Cerebell* is thickest. The medullary part of it, as it approaches the *Medulla Oblongata*, gathers together, and then divides into two Bundles which are joined to the two sides of the said *Medulla Oblongata*, leaving a small opening, where they are divided, called the fourth Ventricle, and its further end, from its resemblance, is called *Calamus Scriptorius*, which is well lined with many small Blood Vessels

for the abovesaid use. As for a further Description, I think it needless, and would be at the least, but very tedious and imperfect, no account being able to represent Ideas of them to those that never saw them, how exact soever it might be given; besides that, Authors have multiplied so many Names for minute parts, that without ocular Information, the Memory cannot well retain them; as the *Processus Annularis*, *Pons Varellii*, *Corpora Pyramidalia*, and *Olivaria*, with the rest of them, which upon turning up the Brain may all be seen, but their uses are not well known.

Then the *Medulla Oblongata*, passes out of the Skull covered immediately with the *Pia Mater*, which even divides along down the Middle, from the first meeting of the *Crura*, to the Extremity of it, at the *Os Sacrum*, in the manner of a Partition. Whence it is, that the Motion and Sensation, of one side alone, may be destroyed by a Palsy, whilst the other side remains free. It also hath a strong Coat from the *Dura Mater*, which adheres close to the other, and not loosely and at a distance, as in the Skull.

Of the  
*Medulla Oblongata.*

It hath a third Coat from the Ligaments of the *Vertebrae* of the Spine, all for its better Security, against any accident that might befall it in its passage.

The bigness of the Brain considered.

As to the bigness of the Brain, it is larger in Men, than any other Animal, in proportion to the bigness of his Body, it exceeding the Brain of an Elephant's in Quantity, and double the weight of that of an Ox, its Weight generally weighing four or five Pounds; though a Sparrow is a Creature exceeding us for bulk of Brains, in proportion to its Body; wherefore it is that they are so falacious and such active Creatures. The Reason of our Brains being so large is, because we have a greater call for Animal Spirits upon the account of the great consumption we make by our Reason, which occasions us to use them several ways which other Animals do not; for which reason Nature hath ordered it so, that we shall diet mostly upon such Food as abounds with more volatile Parts than theirs does. But the natural and mechanical Reason is, because of the pureness of the Animal Spirits, which without a prodigious number of Glands



to separate much of them from the Blood, they would bear but a small proportion to the other Fluids of the Body, and consequently we must be obliged to sleep oftner, which would be highly inconvenient for many Reasons, if no worse Effects were to happen; and this is the true Reason of the great bulk of the Brain. Besides, another ill consequence would follow from a smaller Brain; for there would not be Nerves enough for the whole Body without them; in as much as they are the *Excretory Ducts* of the Glands, and arise from under the middle or inner side of each convolution of them, and by which, by the bye, is certainly the best Mechanism for them in a free *exit* and Passage to the *Medulla Oblongata*; for by that means they lie parallel without crossing or pressing upon one another; for had the Glandular part of the Brain been one even plain covering, or one continued Substance, it would have been impossible for all these medullary Fibres to have passed from them, without Danger and Confusion, especially as they approach near one another, as they recede from the Circumference toward the Center; which must be attended with

*Coma's* and all other Diseases of the Brain: Which places are certainly the seat of those Distempers, whatever the proximate Causes may be.

To conclude then this Chapter, which I have been the longer upon, by reason of the many Varieties, which shew themselves herein, I lastly observe to you, that the Brain, according to the wonted course and œconomy of Nature, is a large conglomerate Gland, the medullary part of which is only the *Excretory Ducts* of the same, which are the origin of all the Nerves, even to the extremity of the Spinal Marrow, sending off Branches to all the parts of the Body, by the way, for Sensation, Motion and Nutrition; of which we shall speak at large in the Chapter of Fluids.

Why the  
Brain hath  
no sense of  
Feeling.

But one thing remains very strange still, that is, why the Brain, which is the fountain of all Sensation, is it self wholly without any. The Reason of which may be, because the Glands themselves are too soft and pappy to cause the necessary ovation or undulation of the Nervous Liquor to the *Sensorium*; or else from the many windings and circumvolutions of their Ducts, which breaks the rebounding Motion of the Animal

Animal Fluid, by the many angles it makes in them; or perhaps from the course of the Liquor itself in the Glands, being contrary to that of the other parts, and so misses or passes by the *Sensorium*, without rubbing the Body of it, which seems to me the most likely Case, and which I shall further shew in my Chapter of Feeling.

And finally, as to the use of the *Cerebellum*, it is by Nature designed to supply the internal parts of the Body with Nerves, as the other does the external; the Brain, without it, not being large enough to suffice; wherefore it is placed in the back part of the Head, separated from the *Cerebrum*, by a transverse *Septum*, which in Brutes is bony, to prevent their pressing too hard upon one another, and frequent concussions upon every little occasion. And thus we see the *Cerebellum* is an Appendix to the Brain, to separate Spirits for involuntary Motions, as Dr. *Willis* says, but not the Seat of Memory, as some think; for that, with all the other Animal Functions, is performed in the Brain only; either in the *Corpora Striata*, or in the *Septum Lucidum*; the last of which, by its safe situation in the very middle of the Brain, surrounded with

The *Cerebellum*, its use.



all, and every part of it, seems a little to speak for its being the Seat of the Soul; the smallness of it being no Argument against it, nor even its simplicity; and as for its singularity, that gives it on our side; for, excepting this, there are Pairs of all the rest.



C H A P.

## CHAP. X.

*Of the N E R V E S.*

**T**H E Nerves of the Body are all so many Organs of Motion, Sensation and Nutrition; each being a Bundle of hollow Fibres, of exceeding small Diameters, one single Hair being as big as a hundred of them. They all rise from the Brain and *Cerebell*, and are a Continuation of the Medullary Parts of them, and are covered with the *Pia* and *Dura Mater*: The first of which, is a proper Coat to each, and every Film of a Nerve, and the *Dura Mater* is a common Coat, and covers a whole Bundle of the other, and commonly goes by the Name of one Nerve; whereas they consist of Thousands.

The Nerves, in their Passage, generally lie very near the Arteries; the reason of which is, that the Animal Spirits may be kept warm, and assisted forwards in their Motion, by the Heat and Pulsations of them; for as the Motion of the Blood is exceeding quick, so contrary to that, the Motion of the nervous Fluid is exceeding slow; the reason of which we shall shew when we speak of that Fluid.

Why the Nerves attend the Course of the Arteries.

Again,

How the  
Nerves di-  
vide, and  
why at a-  
cute An-  
gles.

Again, the Nerves when they part with, or send off any of their Branches, they do it at very acute Angles, that they may, as much as possible, go the shortest way to the Parts they are designed for. And here we must explain, what is meant by the branching of a Nerve: In which case the Substance of the main Trunk of that Nerve is not rent or divided, but only a certain Number of Fibres, which before made part of the thickness enclosed under the *Dura Mater* Membrane, are parted from the rest, and are again subdivided, as they enter their respective parts of the Body; just like the Branchings of Trees, where the ligneous Fibres, that rise from the Root, are continued all the way through the Trunk, till they perforate the cortical Covering, and so divide the main Trunk into many lesser ones, and they again into lesser ones still, whose other Extremities are all singly distinct in the Root; somewhat like unto this is the Case in the branching of the Nerves, which all arise from the Medullary Substance of the Brain, the approaching one another, form a main Trunk under one common Covering, which is perforated a little further, to give way to the Branches which



which are called lesser Nerves, and have all their other Extremities distinct in the Medullary part of the Brain; so that when one end of them is affected by a single Object, it is presently perceived at the other; where the Soul sits in the *Septum Lucidum*, like a Master Organist, and immediately discovers which, and how each organical Fibre was moved. Thus much in general.

The Nerves in particular are reckoned forty Pairs; ten of which come immediately out of the Skull, from the *Medulla Oblongata*, and thirty out of the Pith, from between the *Vertebrae*. The former are weaker and softer than the second, because they serve only the four senses and *Viscera*, and consequently have not so much occasion for being so strong and hard, as the other thirty Pair, which serve both for strong Sensation and Motion. They have equally their Coverings from the *Pia* and *Dura Mater*: From this last it is, that there is such a strict Sympathy, between different Nerves, when either are affected; as for Instance, in the Stone in the Kidneys; the Pain there, draws the Stomach into consent, and causes violent Vomitings; for by the nervous Liquor being

Of the  
Nerves in  
particular.

being stopped by the Pain, it rebounds back to the Fountain, where it likewise stops the Motion of that in the Nerves of the Stomach, and so causes such violent Motions as Vomitings. Thus also it is in Women when breeding, especially of the first Child; which is occasioned by the Distension of the Womb, and a Pressure thereby made upon the Nerves thereof, which stops their progressive Motion, and so occasioning a *Plethora*, which rebounds on the common Sensory in the Brain, whereby the Nerves of the Stomach partake of the same Effect, in some measure, which excites strong Vomitings, the Nerves of it being fuller of nervous Juice than what is necessary for its own free Motion; which is the reverse in Faintings, occasioned for want of a due Quantity of Spirits flowing into their Nerves; either Extreme causing a disorderly Affection. But this is launching too far into the Subject of my Second Discourse, and so I leave it.

The  
Nerves  
which rise  
within the  
Skull.

We shall proceed to a cursory Discourse, or Description of the ten Pairs of Nerves, that immediately proceed from the *Medulla Oblongata*, within the Skull, which is the following. The first Pair are the olfactory, or smelling Nerves

Nerves, which arise from the Extremities of the *Corpora Striata*, and passing through the little holes of the *Os Cribri-forme*, are spread on the Membrane which covers all the spongy Bones of the Nose. They are very soft and hollow, wherefore some have denied them the use of smelling, but without Reason; for it is necessary they should be very open, as well as soft and moist, the better to receive and retain the fine odoriferous Atoms that arrive at them.

The second Pair are the optick, or Nerves for seeing, which arise partly from the Tips of the *Corpora Striata*, and from the *Thalami Nervorum Opticorum*; which last they almost embrace; from whence, passing along, they approach one another, and unite above the *Cella Turcica*, (from whence, as some think, proceeds the Reason why we see Bodies single with two Eyes, which we shall examine hereafter) then dividing again, they pass through the foremost holes of the *Os Sphenoides* into the *Orbit*, where, piercing the Globe of the Eye, on the inside of their Fibres, they are spread on the vitrious humour, and constitute there, the fine *Retina*, which is the Seat of Vision.

Here



Here observe, that the optick Nerve enters the Globe of the Eye, not at its Axis, but at one side of it, because all Vision is lost of those Rayes that fall thereon, as may be experienced, by fixing three Objects, as for Instance, three pieces of Paper, on a Wall, and by standing at a certain Distance, and shutting one Eye, two only will be seen, the Rays of the third, falling upon the Entrance of the optick Nerve, is there wholly lost, without any Sensation. But more of this when we come to treat of the Eye.

Of the  
Nerves  
that move  
the Eyes.

The third Pair are called the Movers of the Eyes, and arise from the *Medulla Oblongata*, on each side of the *Infundibulum*, and passing through the *Foramina Lacera*, of the Sphænoid Bone, they send forth a Branch, which with a Branch of the fifth Pair, forms a remarkable *Plexus*, from whence proceed several Twigs which embrace the optick Nerves, and are spent on the Coats of the Eyes, and send off Branches to the attollent Muscles, depriment and oblique *Minores* of the Ball of the Eye.

Of the Pa-  
thetick.

The fourth Pair are the Pathetick, they are smallest and most inconsiderable, serving only the greater oblique Muscle of the Eyes, upon which they are wholly

ly spent. They arise from a small Medullary Cord, which is behind the *Testes*; thence they go down the sides of the oblong Marrow, and pass under the *Dura Mater*, by the sides of the *Sella Turcica*; they enter the Sockets of the Eyes, through the same Perforation as the former.

The fifth Pair are the biggest of any in the Skull, and the Gustory Nerves; they arise from the fore part of the annular Process, and give Nerves to the *Dura Mater*, and each divides into three remarkable Branches, which again subdivide into others. The first Branch is called *Ramus Ophthalmicus*, because it spreads itself upon the Globe of the Eye, Lachrymal Glands, and adjacent Parts. The second Branch gives Twigs to the Teeth of the upper Jaw, the temporal Muscles, Palate and Muscles of the *Pharynx*; and the third Branch serves the Muscles and Teeth of the lower Jaw, the Cheeks, Chin, and those Parts that belong to the Face; so that they are all so many Nerves in one Bundle, enclosed in the common Covering of the *Dura Mater*, designed some for one part, and some for another, whence their great Sympathy and Consent of Action proceeds; wherefore it is that

The fifth Pair the largest.

the

the Sight, or Smell of any thing grateful, or the Sound of any thing harsh, will make ones Mouth water.

The sixth  
Pair, their  
Exit and  
Course.

The sixth Pair are next, which may be called the Intercostal Pair; they arise from the sides of the Annular Process, but a little below the former, and is but a small Nerve, which passes through the *Foramen Lacerum*, and is spent on the Abducent Muscle of the Eye; but a little before it enters the *Orbit*, it casts off a Branch, which alone makes the Root of the Intercostal, which passes out of the Skull the same way the Carotid Arteries enter, and then joyns with a Branch of the tenth Pair, and with the first, and second *Vertebrae* of the Neck, and forms that large *Plexus* called *Cervicalis*, and so in short, in its irregular Passage, it receives and emits several Branches from and to the several Parts in its Passage along; as the *Plexus Cardiacus*, *Hepaticus*, *Splenicus*, *Mesentericus*, and the other *Viscera*, with the internal parts of Generation, with all which they communicate a little.

The  
Nerves for  
hearing,  
described.

The seventh Pair are the Auditory Nerves. They rise from the hard part of the Annular Process, and enter the hole of the inner Process of the *Os Petrosum*; and then divide into two Branches; the



the one soft, and the other the hard Portion; the first is distributed into the Labarinth, Cochlea, and Membranes of those Cavities, for the Service of Hearing: The hard Portion goes out of the Ear, and serves the Muscles of the Tongue, the *Hyoides*, Ear, Nose, Lips, and Cheeks, giving a small Branch to the eighth Pair by the way; which likewise occasions a general Consent of those Parts, when one Branch only is affected.

The eighth Pair, is the *Par Vagum*, Of the eighth Pair  
the wandering Pair; it arises from the sides of the *Medulla Oblongata*, behind the Annular Process, by several Threads or distinct Beginnings, which, as we said of the Nerves in general, joyn together, and go out of the same hole, where the lateral *Sinus* of the *Dura Mater* discharges itself into the Jugulars. It is joyned, as is said in our last, by a small Branch of the hard Portion of the auditory; as also by a Branch of the *Cervicus Spinalis*, called Dr. *Willis's* accessory Nerve, and then passes out of the Skull, sending off Branches to the *Larynx* by the way; and at the Axillary Artery it casts back the recurrent Nerves, which serve the Muscles and Membranes of the *Trachea* and *Larynx*. When entering the *Thorax*, with the

L former

former Intercostals, it forms the *Plexus* of the Heart, and gives Nerves to the Lungs, Liver, and all those Parts. Dr. *Willis's* Nerve, called *Accessorius*, arises from the spinal Pith, at the beginning of the sixth Pair of the Neck, and, as it ascends to the Head, receives, on each side, a Twig from the five first Pair of Nerves of the Neck, as they arise from the spinal Marrow; then entering the Skull, it passes out again along with the eighth Pair, and is wholly spent upon the *Trapezius* Muscle. The Reason of which Mechanism I cannot well tell.

The ninth  
Pair, their  
Origin and  
Use.

The ninth Pair arises from the *Processus Olivaris* of the *Medulla Oblongata*, and passes out of the Skull, by its own proper hole, in the *Os Occipitis*, and passes to the Tongue, where its Extremities form the *Patella Rotunda*, giving some Branches to the *Os Hyoides* Muscles by the way.

Of the  
tenth Pair,  
and its  
Communica-  
tions.

The Tenth and last Pair arise from the beginning of the *Medulla Spinalis*, by several Threads; then ascending a little, passes out of the Skull at the same hole of the *Dura Mater*, at which the Vertebral Artery enters, passing between the Protuberance of the *Occiput* and the first *Vertebra*, and is spent on the oblique

lique Muscles of the Head, giving three Branches, by the way, to the first and second Pair of the Neck, and a third to the Intercoastal ones.

The Nerves of the *Vertebrae* are <sup>Of the Nerves of the Neck.</sup> thirty Pair; seven of the Neck, twelve of the Back, five of the Loins, and six of the *Os Sacrum*. These all spring from the spinal Marrow, which, as we said before, is no more than a Continuation of the Medullary Substance of the Brain along these *Vertebrae*; which is evident from shaking the Extremities of the Pith in warm Water, which separates into many visible Fibres. The first Pair of the Neck, do not make their *Exit*, at the sides of the *Vertebrae*, as all the rest do, but before and behind, by reason of the peculiar Articulation of the two first Joynts, which would have been apt to have injured them. They serve the Muscles of the Head and Neck; as also does the second Pair. The third Pair, after what it gives to the Head and Neck, sends out the Diaphragmatick Nerve, which is joyned to a Branch of the fourth Pair, and goes straight down to the Cavity of the *Thorax*, and is there bestowed on the Midriff; which makes such a Contraction upon the Neck upon sneezing. The fourth, fifth, sixth and



seventh Pairs, give a few Branches likewise to the Muscles of the Neck and Head; but their largest Branches, with a Branch of the first of the Back, enter the Arms; where, at the beginning, they joyn all together, making a Ganglion or Knot of them, which divides again into fives Branches; the first and innermost is bestowed on the Skin that covers the fore part of the Arm; the second goes to the Palm of the Hand, sending one small Twig to each side of the little and ring Finger, with one to the external side of the middle Finger. The third serves those Fingers the others did not, and likewise the fourth Branch: But the fifth is wholly spent on the Muscles on the inside of the Arm; as likewise the others send Branches to the Muscles, except the first, as they pass by.

Of the  
Nerves of  
the Back.

As for the Nerves of the Back, a Branch of the first Pair, as we said, goes to the Arm; and the ten Pair following run along the *Sinus*, on the under side of each Rib, and give Nerves to all the superjacent Muscles. The twelfth Pair is spread amongst the Muscles of the *Abdomen*. All these Nerves, as soon as they pass out of the *Vertebrae*, send a Branch to one another, thereby forming several small Ganglions.

Those

Those of the Loins are five Pair; Of the Nerves of the Loins. the first and second giving Nerves to the under part of the Belly, and Privaties, as likewise do the third and fourth a little, but their chief Branches joyn, and form the Anterior Nerve of the Thigh, which is disposed on the fore part of it. The fifth and last Pair of the Loins, with a Branch of the former, passes down the Thigh.

The Nerves of the *Os Sacrum* Of the Nerves of the *Os Sacrum*. are six Pair, but come not out of the holes of its back side, but at those of its fore side, and the last between the Extremity of the *Os Sacrum* and *Coccygis*, all for the better Safe-guard and Security. The first four Pair send some small Twigs to the parts in the *Pelvis*, but their main Trunk forms the Sciatick Nerve, which is the very biggest Nerve in the whole Body; which, as it passes down the Thigh and Leg, gives Branches to those parts, and to both sides of each Toe. The fifth and sixth Pairs are but small, and are spent on the Sphincter of the Bladder, and the natural parts. These are all the principal Nerves of the Body, which are so intricately mingled and minutely divided

ded, as to surpass the best Anatomists Art to trace them very far; there being no small Point of the Body, but what hath more or less of them, the entire Animal consisting of nothing else but Blood-Vessels and Nerves, and their Continuations, variously interwoven with each other.





## C H A P. XI.

## Of the L U N G S.

**H**AVING, in the foregoing Chapters, finished the principal parts of the Body, and traced from the Heart, their Origin; we come next to examine, all the other subordinate ones in their Order; and therein to shew, their wonderful Structure, and great Use towards the well-being of the others. Amongst all which, the Lungs, for its nice Texture and Service, challenges no inferior Place; the Frame of it being none of the least considerable.

The Lungs are situated in the *Tho-* The Lungs, why situated in the Thorax.  
*rax*, to be nigh the Heart, and for the Space and Safeguard of the Ribs; but more especially for their free Reception, and many other Advantages of the Air. They are divided into two Portions, by the *Mediastinum*, viz. the right and left, the last of which is commonly divided into two more again, and sometimes, as I have seen, into three small Lobes, that they may expand the easier and freer, especially when they adhere to the *Pleura*, as they do sometimes.

L 4

They

Their  
Mem-  
branes.

They are covered with a double Membrane, the external being a Production of the *Pleura*, and the internal proper to itself, which also covers every single part of it. The real Substance of the Lungs is chiefly vascular; that is, it consists of hollow Lobes, of various Figures and Magnitudes, and yet so well adapted to one another, as to leave little or no waste Places or Interstices betwixt them; these little Bladders have an infinite Number of fine Blood-Vessels, like Net-work, spread all over them, which have many and large Inosculations with each other, for the better Security in Respiration. And all these small Vesicles are no more than the Extremities, and membranous Expansions of the *Trachea*, which takes its Original from the Throat; of a Cartilaginous Substance behind the *Fauces*, consisting, at its upper end, called the *Larynx*, of several Cartilages of a particular Figure, to form the Voice. Then it is made up of Annular Cartilages, which grow smaller and smaller, as they approach the Lungs; but one half of it is membranous behind, for the sake of the *Oesophagus* or Gullet, to give way to it in swallowing. But those of the *Bronchia*, after they

they have passed the Gullet a little, are perfectly annular, and very near one another, which makes them enter each other upon Respiration; though their Capillary Vessels, have only strong annular Ligaments, because the others there, would be inconvenient for free Motion. It is about the fourth *Vertebra* of the Back, where the *Trachea* divides into two, sending one Branch to each Lobe, which are subdivided very often, for the constituting of the membranous Cells or Lobes. And were the Extremities of the *Trachea* not membranous, but retained their Cartilaginous Substance still, they could not have subsided in Expiration, which would have disappointed the advantage the Blood gets from the Air.

The Cartilages of the *Trachea* or Wind-Pipe are tied together with two Membranes; the external composed of circular Fibres, and the internal Lines within with many Glands, to keep it moist and smooth, which when dry or stopped, cause a Hoarseness. It is exquisite in Feeling, and hath its Fibres of several Directions, the better to assist the *Trachea* in Coughing. This being the Condition of it, before it enters the Lungs, it looses this form afterwards,



terwards, and composes all those little Bladders, that make up one half, if not more, of the said Lungs, which hang so thick round the Branches of the former, like Grapes upon their Stalks, which is continued through the whole Structure and Mechanism of this Engine, its whole vesicular Substance being but a continuation of the *Trachea* enclosed in the Membrane *Pleura*, together with the Blood-Vessels from the Heart, viz. *Vena* and *Arteria Pulmonalis*, the Bronchial Artery, and some small Threads of the eighth Pair of Nerves, all which together, I say, make up the entire Substance of the Lungs. For wherever there is a Branch of the *Trachea* or rather *Bronchea*, there is always a Branch of the Pulmonary Vein on one side, and a Branch of the Pulmonary Artery, with a fine twig of a Nerve on the other, together with a few fine Glands.

Why the Lungs not of a red Colour.

The colour of the Lungs in a *Fetus* or Infant unborn, is of a Purple red, but in Adults they lose that red Colour, and are always pale; the Reason of which is, because the Vesicles of the Lungs of a *Fetus* lying flat and close, the Blood can reflect its colour more distinctly through them, than afterwards

afterwards, when those Vesicles are opened and expanded by the Air, whereby many Rays are then lost in their hollow Cavities, and those that are reflected, chiefly proceed from the external Surface of them, and therefore must be of the colour of the carnous Fibres, though in reality they contain more Blood in Quantity than before.

Now the Mechanism of the Lungs being once well known, we shall easily learn the great Effects produced in them by the Air. The Lungs of a *Fetus* are very close, they having never as yet taken in Air into them, having that supplied them by the Blood of the Mother, by the Navel-string; therefore they breath not in the least till born; for which reason their Lungs are specifically heavier, and will sink, if put in Water before Birth, but if they have but once breathed, they will swim, their Surfaces being thereby made much larger than before; which observation is useful to know, upon occasion, whether a Child is born alive or not.

No Creature breaths before born.

I say, as no Animal can, nor hath need for breathing whilst in the Womb, and floats in a liquid Substance, it is utterly impossible it should breathe; but

How Breathing is first caused.

as

as soon as it sees Light, and its Mouth comes under a column of Air, it by its Elasticity, there being a previous *Vacuum* in the Lungs, rushes down the *Trachea*, and presently dilates the Lobules, which sets all the Muscles of the *Thorax* on Action, which when once begun, can never be stopped again till Death. And the Lungs being thus blown up by the Air, unravels all the Vessels thereof, by which means a free and new Course or Passage is made for the Blood, which before passed off by the *Foramen Ovale*, the sides of which *Foramen*, in time, are squeezed together, by the pressure of the Blood in Expiration; from which Action of Expiration, there results also no less an effect than the formation of Blood into Globules, as we are to shew by and by.

The true  
use of the  
Lungs.

Many are the uses ascribed to this Bowel, some thinking it serves as a Cooler to the hot Blood, that comes from the right Ventricle of the Heart; but as to this use, I shall leave it for those that are of more value, only adding this, that it is so far a Cooler that it is a Kindler, by breathing in pure Nitre from the Air, which Experience teaches us, is the *Pabulum Vitæ*, without which we could not long subsist, and



and where it is wanting Death ensues; as we find in Mines, that are troubled with Damps. The main uses of the Lungs then are these: To receive Air and Nitre into the Blood, to form *Globuli*; to press, squeeze and break the cohering parts of it, by the pressure of the Air, which may easily be demonstrated to be equal to an hundred pound Weight, thereby keeping its Globules at a due distance, from attracting one another, and to keep up their Rotatory Motion around their Axis, whence proceeds the heat of the Body. Another use is, to assist and carry on the Circulation of the whole Mass more steady and easier for the Heart, by removing the pressure of the Atmosphere a little off the Lungs in Expiration, whereby letting the pressure on the whole surface of the Body exert itself, and squeeze in the Blood out of the Veins and *Cava* into the Heart, to be afresh comminuted by the Action of the Lungs, so that indeed, the Heart may be called the Vessel of Circulation, but the Lungs is the true Machine of Sanguification.

Now as the Lungs are but so many  
 bladders for all the Air to act upon,  
 and together by Blood Vessels and fine  
 Membranes,

How Con-  
 sumptions  
 are caused  
 in this  
 Country.

Membranes, serving for such laborious Uses, and are in themselves merely passive, it needs be no wonder, why our Country is so subject to Consumptions, which are occasioned first, by the Qualities of the Air fouling our Blood, and causing a slow intermitting Fever, and not being able to extricate itself of these fœculencies, deposits them on the Lungs, where in time they obstruct the Glands, which afterwards produces a small Excoriation, which again being assisted by fresh Causes, becomes Ulcerous, and so ends at last in a downright Consumption.

How Respiration is performed.

Since the Lungs then are passive, it may be asked, how is Respiration performed? This, as we have said, first began by the Air's rushing into the empty *Trachea* at our Birth, and is assisted by the Motion of the Ribs upwards, by proper Muscles, which elevate them so as to make right Angles with the *Vertebra* which draws the breast Bone outwards, thereby making room enough for the Lungs to be dilated without Friction, this being one half of Respiration, called Inspiration: The other part of it is performed by other Muscles and the *Diaphragm*, which serve to pull down the Ribs again and compress the *Thorax*, there

by straightening its Cavity and thrusting the Air out of the Lungs. And thus by these two Causes repeated alternately, Respiration is produced and continued. The Number of the Muscles which conduce towards these Motions are reckoned by *Neuwentyt* to be no less in Number than an hundred.

Vid. *Neuwentyt's* religious Philosopher, V. 1. p. 46.

Another use of the Lungs is, together with the *Larynx*, to form the Voice, and to assist our Smelling, by excluding the Air, in the first Case, and snuffing it in, in the latter. The Lungs have also some Lymphaticks, though very few, which discharge themselves into the Thoracic Duct. They are much smaller, and make more frequent anastomoses, than is observable in the rest in other parts of the Body; the reason of which is easily solved, for as there is but little Secretion here, few Lymphæducts are required; and as the Action of the Lungs is irregular and presses hard upon them, it is necessary they should anastomose often to prevent Obstructions: And it is necessary they should be fine; for were they large and their Coats of the same thickness, they would be often subject to burst: But as the Lungs, in Expiration, throw out much Serous Moisture, there is the less



less need for them, the steam of our Breath amounting to half a pound Weight, in twenty four hours times.

The cause  
and mode  
of our  
Voice.

Lastly, let us now examine the Cause and Mode of our Voice, and see, whence the great Varieties thereof proceed. In which I shall not be tedious in rehearsing the particular Muscles of the *Larynx*, which may be found in every Anatomical Author, and are in all eight Pair; all which are inserted into the Cartilages of the *Larynx*, to the end that the Wind-Pipe, and its Orifice, may be several ways lengthened and shortened, dilated and contracted, as the certain or several Modifications of the Voice shall require, for a more shrill or deep Sound, as we have occasion to use it. For this Reason also it is, that the *Trachea* and *Larynx* are made of a Cartilaginous Substance, to keep the Passage for the Air free and open, and to give smarter Vibrations to the Air, which a membranous Substance would do but little in, and a bony one much less.

The Cartilages that form the Voice.

The distinct Cartilages that are peculiar and necessary for modulating the Voice are first, the Cricoides, or Ring-like Cartilage; this is round and thickest behind, the better to guard off the Gullet,

Gullet, and grows narrow towards the fore part of it, and joins immediately to the *Trachea*, and is the Basis upon which the other stands on. The second is the *Scutiform* one, because of its likeness to a Shield: It makes a sharp protuberance before, called *Adam's-Apple*; concave within and convex without; the better to collect the Air: The like Art you see in Hydrostatick and Pneumatick Engines. The next are the *Arytenoides*, which reach from the middle of the fore part of the former, the back and upper part of the Ring Cartilage, which are the chief Modulators of the Voice, and answer to those chink-like Partitions in Trumpets, for the Air to strike upon, and receive various Modulations, as they are nearer to, or further from each other. Betwixt these Cartilages and the Thyroid, there are two little Cavities externally, framed by their Membranes and Muscles, into which, if any Liquor or hard Body enters, as it often happens, it will provoke great Coughing, by the tickling or irritation of these Causes; for the *Larynx* itself is so well guarded, that it is impossible any Substance should pass into it (as is commonly thought) by the *Epiglottis*, which is the fifth Cartilage, and

M                      resembles

resembles a little Tongue, whose Base is fastened to the inside of the Thyroid Cartilage, and very elastick; so that when we swallow our Food, it, by passing over it, presses down the point of it over the Chink, and so guards the Wind-Pipe from any annoyance or inconveniency that might happen without it; but as soon as the Food hath passed it, its own Elasticity makes it bolt up again, for the free Passage of the Air into the Lungs; therefore it is that we cannot swallow when we speak, nor speak when we swallow.

It is a common Notion, that an Elephant is greatly afraid of a Mouse, and therefore, when he sleeps, always takes such care beforehand, the she may not be troublesome to him; the Reason of which, Mr. Ray says, is, because they have no *Epiglottis*; wherefore a Mouse chances to run up his *Proboscis* she may get into his Lungs, and so still him; therefore, when he sleeps, he always keeps his Trunk so close to the Ground that nothing but Air can get in between.

That these Cartilages may always be moist and glib, and fit for their vibratory Office, and from being exposed to the drying Air, and heat of the Lungs Nature hath provided, besides those small Glands

Vid. Ray's  
Wisdom of  
the Creati-  
on, p. 352.



Glands that line the inner Membrane of the *Trachea*, several little ones around the *Epiglottis*, the Almonds and two large ones, situated on each side of the Thyroid Cartilage, from whence they take their Name. All Matters being thus providently considered, we proceed to speak of the Voice, and its Varieties.

Now the Voice is that certain Motion of the Air through the *Trachea* and *Larynx* upon Expiration, which is more or less smooth and loud, according to the bore and smoothness of the said *Trachea*, and the force with which it is expelled out of the Lungs. But the *Trachea* alone can make no other difference in the Voice, it next passes through the Chink, which is formed by the two foresaid Arytenoid Cartilages, by which it is particularly modified into so many Notes, as there can be different Apertures made between them; which causes grave or acute Sonnds or Notes, as they are closer to, or further from each other; for as the *Glottis*, or the Chink of the *Larynx*, can open and shut by the Action of its Muscles in innumerable ways and degrees, from thence will arise different Notes or Tones, which by Musicians are called Acute or Grave, and all occasioned

Whence  
the difference of  
Notes proceeds.

by a swifter or slower Repercussion of the undulation of the Air, by these said little Cartilages, which is performed quicker or sharper, by bringing 'em closer and so narrowing or straightening the Passage or Chink; and duller or graver by the very reverse Modulation of the *Glottis*; whence it followeth, that upon the Chink being too much dilated, the Sound or Voice is quite lost or destroyed, in them who endeavour to produce a graver Sound than they are able to effect; so likewise the same happens, but from a contrary Cause, in the Formation of the acuter Sound, which almost causes a Suffocation, or, at least, but a very disagreeable squeaking Note.

How different Notes are produced.

To prosecute this Subject yet a little further, suppose this Chink or *Glottis* to be contracted as close or narrow as can be, to produce the sharpest and highest Note, and the Air to be propelled into it uniformly; it certainly follows, that as the two little Cartilages, are in the foresaid Condition, they must be very Tense, and consequently their Vibrations or Motions, caused by the Air, will be very short and quick, which is all necessary to form a sharp Note; and so, all the Notes from the highest

highest to the lowest, and back again, may be successively founded, only by dilating the Apertures of this Chink gradually, and in exact proportion to one another, which fine Fingers are able to do, and is all that causes their Voice to be so Musical.

Again, to illustrate this Matter still Further illustrated. a little more, this being the Case of every single Note; namely, the Number of Vibrations produced in a given time, it follows, that the same Note may be made strong or weak, and yet the same Note, only by increasing or diminishing the Force of the Air through the Chink, and altering of the Aperture of it accordingly, and thus by encreasing the force of the Air, (which is always proportionable to its Quantity thrown out of the *Larynx*, in founding of a single Note) and placing the two Cartilages at such a distance, that the Air shall pass from between them with the same degree of Velocity, as before, when the Chink was narrower, the same Note shall be founded, but much stronger; so that a single Note depends only, on the Number of Vibrations in the same time, and may be made weak or strong, and yet the same Note, by more or less striking on the Cartilages; and so



any Note may be founded, in all degrees of Strength, provided the Aperture of the *Glottis* encreases proportionably, that a great Quantity of Air may pass thro with the same Velocity, as the lesser did before in founding it weakly.

But on the contrary, if you would heighten the same Note, only by encreasing the force of Air alone through the *Glottis*, and make no alteration in the largeness of the Chink, it would not continue the same Note, but found a much bigger one; because as the Velocity of the Air is augmented by the greater Quantity passing through the same Chink, in the same Time, the number of Vibrations must be proportionably encreased, and consequently a new Note produced, much sharper than the former.

Somewhat like unto this is the case in Musical Instruments, where the less or smaller the String is when struck upon, the sharper or acuter the Sound will be, and for the same Reason that a small Aperture of the *Glottis* makes the same; namely, from the many Vibrations performed on the Air in a determinate time; whereas on a large String or one not very tense, it makes but few Vibrations, and therefore hath a

grave Sound or Note. And these are the chief differences of Notes, which depend upon the number of Impulses upon the Ear in a certain time; and not upon the direct strengths or *momenta* of those Impulses, as the differences of Colours do; which indeed makes the Sound more or less hard, but never alters the Note; that is always the same, whether it vibrates through greater or less Space, provided they are performed in the same time; somewhat like unto the nature of a Pendulum, that shall oscilate through unequal Arches in the same time: And it hath been found, that two hundred and twenty-two Vibrations of a String or Viber in one second of Time, makes the Sound of *G. Sol. re, ut*, in the Scale of all Musick.

Vid. *Hook's's*  
Posthu-  
mous  
Works, p.  
10.

But since Sharps are the quicker Vibrations of Musical Bodies, and Flats are the slower ones; one unskilled in these Studies, would be apt to think, that the Air moves swifter, and carries the Vibrations quicker to the Ear, in one, than it does in the other; which is not so, for both reach the *Tympanum* in the same time, only more of the short Vibrations than of the long ones; as Sound is no more than conden-

fed Air striking upon the Drum of the Ear, as soon as the condensing force ceases, the condensed Air begins to expand, and in expanding condenses the next adjacent Air, which afterwards expanded also, condenses the Air next it, and so is continued from the first Collision to the Space all round, in a true Sphere, whose center is that point where the Condensation or Sound first began. Now it is evident, that these Oscillations are not all equal; for acute Sounds make but very small, and grave Sounds very large ones, which propensate for the Difference of their number of Vibrations, and so move at last with equal Velocity, a grave Note arriving at the Ear, as soon as an acute one, so that what the last gains by its quickness, it looses by the smallness of its Waves; and what the other looses by its slowness, it gains by the great swiftness or length of its Waves; and so the times from the first point, at equal Distances, are always equal; which is what was wanted to be proved; and in doing which I am obliged to make my Expressions the more familiar, that they may be better understood by those they were designed for.

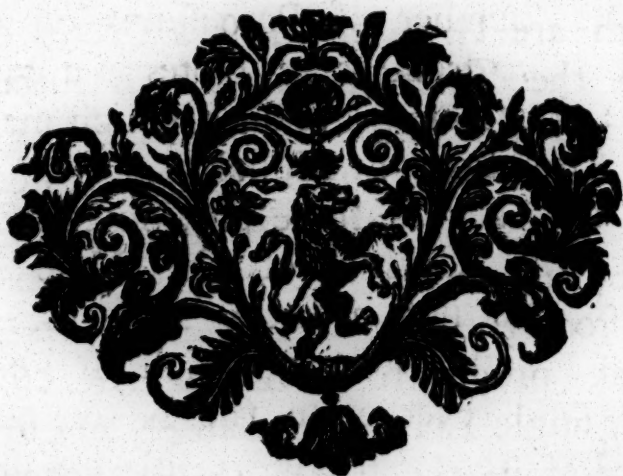


This being the Case in respect of Sound, and of the different Notes thereof, so far as it respects the percussing Body, and the Air struck upon, we may at once solve the *Phænomenon* of it, as it regards the *Sensorium*, by considering the many Impressions the acute Notes makes to one grave one thereon, in any certain determinate time; for though all Sounds and Notes, in their Motion, are uniform, and keep the same Velocity from the beginning to the end of their Course, yet there are a greater number of Percussions on the *Tympanum* from acute Notes in a given Time, than from grave ones, which makes the Alterations in Musick.

How  
Sounds af-  
fect the  
Sensorium.

Lastly, besides these previous Advantages, the Cavities of the Nose and Mouth, do not a little assist us, in forming right Sounds, which serve to retain and reverberate the Notes, making them the more powerful and pleasant, like the hollow of a Violin, as the loss of them evidently proves: For which reason, the Dimensions of the Mouth, are altered proportionably to the Notes formed in the *Glottis*; low ones being always attended with a Prolongation; and high ones with a Contraction of its Cavity. And thus we see,  
that

that the Differences of our Voices arise wholly, from the different Bores of the *Trachea*, *Epiglottis* and Jaws. This I have dwelt the longer upon, as it is a curious Subject, and do herein find another mechanical Instrument of the Body; namely, a Bellows or Bagpipe, subject to the same Laws as all other Pneumatick Engines are.



## C H A P. XII.

*Of the* L I V E R.

**T**H E next Bowel that succeeds the the Lungs, both in Situation, Structure, and Use, is the Liver. It is the largest *Viscus* in the whole Body, filling most of the Cavity of the *Abdomen*, and situated on the right side, for better Security and Convenience, being well fastened by the Ligaments, which are two; the first a strong one, from the *Peritoneum*, which suspends it; and the other the umbelical Vein, turned into a Ligament, to keep it steady.

It is, as all other *Viscera* are, enclosed in a double Covering; the external from the *Peritoneum*; and the internal, proper to itself, which covers every single Lobe immediately, and every Gland of it, the better to assist them in their Orifices, and prevent their interrupting one another. It is very thin, and, on its Surface, run the Lymphaticks that arise from these Glands, which are very numerous too, by reason it is for thick Fluids, so that there is occasion for many of them, to carry off their several parts; which makes this part, especially



ally in a stubborn Jaundice, to be so often the Fountain of Dropsies. It is situated under the short Ribs, for the better Security; convex on the outside, and concave within, that it may be at rest from any unnecessary Motion, which would but disturb it in its Office.

The Substance of the Liver, the Reason of it.

The Substance of the Liver is but a heap of Glands, of a conical Figure, like so many Stones of Raisings, all and each cloathed with their proper Membrane, and are like unto other Glands of the Body, in the general Structure, as being but a complicate of Circumvolutions of capillary Arteries, which compose their Substance, I mean the *Vena Porta*, which serves the same Office, and hang at their Extremities like Bunches of Currans, from which each Gland receives a Twig, which, with those of the Intercoastal Nerves and its Veins, constitute the whole Substance of the Liver, taking in some small Branches of Arteries, from the Coeliac and superior Mesenterick. The Glands themselves are in distinct Clusters, enclosed separate, and united by their Membrane of an uncommon Shape, which proceeds from their compounding Arteries and *Secretory Ducts*; being the most complicated, and of the largest Diameters of any in the Body.

*Vid. Malpighius L. de Hepar. c. 2.*

The

The use of the Liver is, to separate <sup>The true Use of the Liver.</sup> a thick Portion from the Blood, to make Choler of, and not for Sanguification; nor to receive the fresh part of the Chyle, as was formerly thought, but for the foresaid use, and which *Hippocrates* <sup>Vid. Hippocrat. L. de Morb.</sup> himself clearly signifies, where he says, *The Heart is the Fountain of Blood, the Seat of it is the Liver.*

The *Secretory Ducts* of every Lobe, <sup>The Secretory Ducts and Excretory.</sup> joyning together, form the Excretory ones, whose use is to carry off the said Bile, as it is separated from the circulating Mass of Blood, through the Liver. The *Excretory Ducts* of the Liver arise from every Gland, and uniting, form that called the *Porus Biliaris*, whose Trunk is of the bigness of a Goose-quill, which joyns the end of the Cystick Duct, with an oblique Insertion, with its Mouth towards the common Duct, so that it is impossible, they should communicate with one another, except this last is quite obstructed. Through these Vessels the Bile perpetually flows into the common Duct, and so into the *Duodenum*. But as upon eating fresh Food, more Bile is needful than what the former Discharge furnished, Nature hath provided another *Secretory Duct*, or Vessel, the Gall-Bladder, to be as a Repository, or Store-house

house, to keep it in, till wanted; for which reason, it is situated in the concave part of the Liver, on purpose, that the Stomach, when very full, may press upon it, and so cause the Bile to flow out of it in sufficient Quantity, ready against the Aliments arrive at the *Duodenum*. It is of the bigness of an Egg, consisting likewise of three Coats, of shape like a Pear, with its bottom downwards. The Bile is brought into it, by some smaller Branches of *Secretory Ducts*, which arise from the neighbouring Glands, much thinner in Consistence than the Bile of the former, and which unite from one or two Pipes, which enter it near the Neck, the Passage of which Entrance is called the *Cystick Duct*, which, as we said, meeting with the *Porus Biliaris*, or Hepatick, forms the common Bile Duct, which enters the first Intestine with a great Obliquity, that nothing may pass out of them, or into it, to obstruct the Motion of the Bile; for there are no Valves at any of the hepatick Conduits, as in other places of the Body, because that would be of ill Effect.

The Liver  
why so  
large.

The Liver is of a great bigness, because its Secretion being very slow, fewer Glands could not have served. Its Lymphaticks are many and large, which open



open into those Glands near the *Vena Porta*, and thence go to the Receptacle of the Chyle; and was not the Motion so very slow through the *Vena Porta*, as it is, there must have been many more, than, under the present Case, there are of them. We have spoke of the *Vena Portarum* in the Chapter of the Veins. He that hath a mind to know more of the Structure of the Liver, may steep it two or three Days in hot Water, and wash it well, by which means it will become so white, as to discover all the little Lobes thereof, with the small Glands which compose the chief of its Substance.

To conclude then with our Analogy, we see, the Liver is no more than a certain Number of Arteries circumvoluted under a common Membrane; which constitute this great Bowel with all its *Excretory Ducts* and *Pelvis* the Gall-bladder, observing all along the common order of Nature in its Substance and Mechanism, made up of Blood-Vessels, Nerves and Glands, only with this Difference, receiving its Blood by Veins instead of Arteries. The best Authors upon this Subject are *Glisson*, Anatomical Professor at *Cambridge*, and *Malpighius*; to whom I refer the Reader.

## C H A P. XIII.

*Of the S P L E E N.*

**T**HE Bowel next to the former, and succedaneous to it is the Spleen; whose Nature and Use hath but of late been rightly found out. It is situated on the left side under the *Diaphragma*, between the Ribs and Stomach, above the left Kidney; of a Leaden Colour in Adults, but red in the *Fœtus*, because their Globes of Blood are much smaller, and so reflect a brighter red. It hath likewise two Coverings; the external common from the *Peritonæum*, and an internal one proper to its own Substance, and much finer than the former.

The Substance of it is soft and spongy, full of little Cells, made up of fine Membranes, which communicate with one another, and are always full of Blood, thicker than that of other Parts; for which reason it is not of so high a red, but of a dark bruised-like Blue Colour. At the Extremity of the Blood-Vessels of it, as *Malpighius* says, there are many Glands, of an oval Figure, which, when cut, fall into themselves; which

which shews them to be hollow, and not like other Glands in the Body. Its Fibres are not irregular, as those of other Membranes seem to be, but come from innumerable Parts, says Dr. *Keil*, as Rays from so many Centers, where the Fibres of one point are regularly interwoven with the Points of those surrounding of it.

It hath likewise a few Lymphaticks, which empty themselves into the Lumbar Glands, and carry off the thinner parts of the Blood from the Spleen, that the rest may be thicker, and its Motion slower, for the proper use it is designed for.

As to the use of the Spleen, many have been the Opinions of Authors about it; the Antients taking it to be a Receptacle for the *Atra Bilis*, a humour no where existing in the Body. Some thought it to be a sanguifying Bowel, as they thought of the Liver; which was the Opinion of *Piso*, *Spigelius*, *Vesalius* and others. *Glisson* thought it made Alimentary Liquor for the Nourishment of the Nerves; and *Helmont* took it to be the seat of the sensitive Soul; all which are very empty, and to no purpose, but to shew the different Sent of their Thoughts, every one affirming

Of the use  
of the  
Spleen.

N

firming



firming what he was most inclined to imagine. But since mechanical Reasoning hath come into Custom, in these like Studies we may find a better account of it from Dr. *Keil*, and a better use for it, than any hitherto laid down. We must consider then, that as the Bile is a very thick Liquor, and the Liver is so nigh the Heart, and the Velocity of the Blood from thence is too quick, to have such large Particles, as the Bile consists of, separated therefrom; therefore to correct and amend this Inconvenience, the Blood is brought hither, from the Coats of the Stomach, Guts and *Omentum*, by the Branches of the *Vena Porta*, whereby the strong Current and rapid Motion of the Blood is much quashed and made fit for a slow Circulation through the Liver, to have the Bile separated from it: But because all these parts are not sufficient to receive all the Blood which is necessary to be sent to the Liver, therefore Nature framed the Spleen, to supply this Defect, without which so great an Inconveniency must follow, but the Blood being poured into its Cavities by a small Artery, moves as slow as any other that enters the Liver, and consequently a sufficient quantity of Bile

by this means secreted; which could not be done, without the Spleen, by the Liver alone; from whence we may conclude, that the Spleen is a necessary part, and that it cannot be cut out and Life long preserved.

And that this is the true use of the Spleen is evident, for as much as the Spleen is not like the other glandular bowels, nor hath any Excretory Pipe or Duct to convey any Secretion; therefore it serves to collect and retard the Blood a little, that it may pass on gradually to the Liver, to be there made further use of, for the Secretion of more Bile; for the slowness of its Motion and Secretion, must needs require a great Quantity of Blood to flow thither, or otherwise such a large and continued quantity of secreted bile, could not be constantly kept up and continued, as we find it is.

Hence we may plainly know the reason, why as our young Men in this Country are subject to Consumption, so why our Children have too hard and tumified Spleens. Because the spleen, being altogether of a spongy substance, when the Blood becomes too thick, as in our intermitting Fevers in *Effex*, which Children, from their ten-

The true use demon-  
strated.

Why the Spleen sub-  
ject to Tu-  
mour.

der Constitutions, and mismanagement of Nurses, are so subject to, so that it is apt to stop here and distend the Cells of the Spleen to a vast bigness; it being, by its open and unguarded Substance, and by the natural slow Motion of the Blood through it, the most subject to Distension.

Why the  
Blood is  
conveyed  
by the *Vena Porta*.

Again, another Argument to prove this to be the true use of the Spleen, I take to be, the round-about Course the Blood takes from it to the Liver by the splenetick Branch, which might have been more speedily convey'd into the *Vena Cava*, which lies so very near it, had not its Blood been particularly designed for the Liver: So that, I say, as this is the true use of the Spleen, though an Animal may get over the Danger of its being cut out, and may seemingly live in Health for some time yet for want of a necessary Quantity of Bile separated, as usual, the Chyle must not be so well prepared as before, but carry many acid and gross Particles along with it into the Blood, which in time would occasion a general Discreasy in all the Fluids of the Body, and end in Death at the Last.

CH A



## C H A P. XIV.

## Of the PANCREAS.

THE *Pancreas* is another glandular Bowel, a loose and shapeless Body, lying under the Back and lower part of the Stomach, upon the first *Vertebra* of the Loins, across the *Abdomen*, reaching from the Liver to the Spleen, covered and tied fast by the *Peritonæum*, weighing commonly four or five Ounces, and about six Fingers breadth long, two broad, and one thick. Its Substance is altogether Glandular; of a hard Consistence and a globular Shape; and each hath a globular Shape, and an Excretory Duct, which uniting, form at last that single large one, called from its first discovery, *Ductus Wirsungianus*, which runs through the middle of the Bowel, receiving from all Parts innumerable little ones, opening into it, from whence it passes into the Intestine, which it enters about five Fingers breadth below the *Pylorus*, in a remarkable Wrinkle of the flexure of the *Duodenum*, having a small Caruncle covering its Orifice, to keep its Channel clear of other Bodies from getting in.

Its description and situation.

Its Nature  
and Use.

As to the use of this Bowel, it is merely to secrete a Lymph, to mix with and dilute the Chyle, and the Liquor secreted by the Glands of the Guts, that it may the more easily enter the Mouths of the Lacteal Vessels, and may not attract one another's Parts, before they get under the attrition of the Heart and Lungs.

As to its Blood-Vessels, we said before, they come, as do most of those of the superior Bowels, from the Coeliac Artery, and return into the splenic Branch of the *Vena Porta*, like as the rest do. It receives its Nerves from the Intercoastal.

The Use  
of the *Thy.*  
*mms.*

And here under this head, I shall consider another glandular Body like unto this, called from its Figure, the Gland *Thymus*, which is situated in the upper part of the *Thorax* under the Clavicles, where the *Cava* and the *Porta* divide into the Subclavian Branches receiving Arteries and Veins from the Carotid and Jugulars, and Nerves from the eighth Pair. From its remarkable bigness in Infants, and its growing less as they grow in Age, it is evident, that the use of it was more particularly designed for the benefit of the *Fetus*: But what this use is, is not rightly fixed upon yet; though a learned Author sup-

poses it to be for a *Diverticulum* for the Chyle in the Thoracik Duct of the *Fætus*, whose Stomach being always full of that Liquor, in which it swims, must keep the Thoracik Duct full of Chyle, because the Blood, which the *Fætus* received from the Mother, fills the Veins, and hinders the free Entrance of the Chyle into the subclavian Vein, which is a nice account of it indeed, could we be certain it was so: But may it not reasonably be thought, with submission to the Learned, only a large Lymphatick Gland, serving to pour Lymph more plentifully into the Thoracik Duct, thereby raising up the Valves of the subclavian Veins, and so assisting its entrance into them, and also abundantly to dilute the Chyle just upon its Entrance, to prevent any unequal mixture thereof, which the *Fætus* is more subject to, its Blood moving but slowly, and not having the advantage of the Air in its Lungs, to comminute it, when entered, as Adults have.

And what makes me rather think so, because its Excretory Ducts discharge themselves into the Thoracik, and have Valves to hinder any Fluid from passing back that way. But then, may one not ask, what is the Reason it is not always very large? If that be the right



use of it, I answer, for the same Reason that our Breasts or Mammary Glands are not: For most certain it is, that they secrete Milk once, which we feed upon by the Mouth, though now they are dry and so far useless, the great *Plethora* of the Vessels being now removed.



C H A P.

## C H A P. XV.

## Of the KIDNEYS.

THE Kidneys are the next necessary parts in an Animal Body, <sup>The Kidneys, why two.</sup> and no less useful than the former; for as we drink often, and more than what is just necessary for the Blood's Motion, it is fit and requisite, that there should be proper outlets of this *Serum*, upon urging Occasions; for which reason, the Body hath two Kidneys, lest one should be injured. In which case, Nature deviates from her common Custom, where she makes but one *Viscus* of a Sort; and the Reason of it is, that one may serve, when any Misfortune befalls the other, or because one of the same bigness is not sufficient to secrete fast enough, and to make it equal to both, which would be inconvenient, besides taking up Room; for it must have Emulgent Vessels of a bigness proportionable to it, which would weaken the current of the Blood too much in the *Aorta*, and consequently incommode its Circulation through the other parts of the Body: Therefore, I say, there is one on each side, whereby all Advantages are acquired, and no inconveniencies

conveniences occasioned, which could not otherwise be effected.

The right Kidney lies under the Liver, and the left under the Spleen; and as all the *Viscera* have two Coverings; one common from the *Peritonæum*, and the inner proper to their own Substance, so have these the internal, from the external Coat of the Blood-Vessels. They are well guarded with fat, to defend their Vessels from being corroded by the acrimony of the Salts, and to keep them warm, the better to separate the *Serum*.

The Mechanism of the Kidneys

Their Substance too, like unto the other *Viscera*, is Glandular. The Emulgent Arteries that enter them, ending in fine round Glands, which make the external Substance of them, about half a Finger thick, from each of which goes a long small Tube (as the Medullary ones do in the Brain) and compose the inner Substance of the Reins, and are the proper Excretory Ducts of the former; and the nearer they approach one another, make the fewer and wider Pipes, which, by raising the inner Membrane of their Extremities, form those little Protuberances called *Papillæ* or Caruncles, which are visible in the *Pelvis* or Cavity of each Kidney.

The left Kidney is generally bigger than



than the right, occasioned by the situation of the *Aorta*, being more on that side, and striking harder upon it, thereby causing somewhat greater accretion of Nervous Juice in the Fibres of that, than in the other. Their Shape and Figure is like unto a Kidney Bean, that being the most capacious form, next unto a Sphere or an entire Circle, to contain the greater Number of Glands, as likewise for the more commodious Concentration of the excretory Tubes, through the Caruncles into the *Pelvis*, as so many *Radii* from the Circumference to the Centre. And thus we see, the Structure of the Kidneys is like unto that of the Bowels in general, and differing only in a few particulars, relating to the different Diameters and Convolutions of their Ducts, their Shape, Position and the like; which also makes them of so hard and solid a Substance beyond any of the others; whereas the Liver and Testicles are not so firm as they are, because their Secretory Ducts are much wider, and their Interstices larger, and consequently must be much lighter and softer than the former.

In the inner side of the Kidneys, there is a Cavity, in each formed by the Dilatation of the Ureters, called the *Pelvis* or Cistern, into which the Urine first flows, and which are the seat and first bed

Their shape  
and figure.

The *Pelvis*.

bed for those Stones that grow in the Kidneys; which sometimes, by reason of the situation of the Kidneys, at the Insertion of the *Psoas* Muscles, cause a Compression upon them, and so occasion that numbness of the Thigh, which sometimes happens in a Fit of the Stone.

The Ureters.

From these Cavities proceed two long Tubes, which like all other Canals of the Body, are composed of three Coats; a Membranous, a Muscular, and a Nervous one. They pass from the Kidneys to the Bladder in the form of the Letter S, and enter it near the Neck very obliquely, as the Bile Duct does the *Duodenum*, to prevent the Urine, upon any occasion, from regurgitating back upon the Kidneys, in the room of a Valve; or otherwise, by reason of the Bladders often distention with Urine, it would not have been so convenient, but its sides would have been squeezed together, and would in time been made useless. These Ureters are as Excretory Ducts of the Kidneys, and the Bladder is their Cistern, into which they discharge their Fluid.

Of the structure and use of the Bladder.

The Bladder is the Receptacle of the Urine, made of the expansion of the Ureters, to receive and collect their Fluid to some Quantity, that it may be voided all at once, whereas without it we should be continually dropping our Water, which would

would be very troublesome to us, and contrary to the wise Order of Nature, in respect of the Provision made in other Cases. Its Substance is exactly like that of the former, consisting of three Coats with Glands on the inside, to lubricate its Surface, and guard it from the acrimony of the Urine, which, like the inner Membrane of the Stomach, is full of Wrinkles to facilitate its Dilatation without Pain.

It is rightly situated at the bottom of the Belly, between the Duplicature of the *Perritoneum*, there being spare room for it, between the *Os Sacrum* and *Pubis*, before the straight Gut in Men and *Vagina* in Women, its Orifice penetrating in them thro' the *Vulva* at the Root of the *Clitoris*. Its Figure is Spherical and not like a Pear, as hath been thought, being, by the weight of Water, biggest near the Neck. When it is full, the *Plethora* of Nervous Juice on its Fibres, caused by the pressure of its Fluid or Acrimony, occasions all the Fibres of its Muscular Coat to contract, and so expel its Contents, which being over, the former super-abounding Force ceasing, the Sphincter by its elasticity, naturally shuts, and, by the Nervous Juice in its Fibres keeps all close, till the former Cause acts afresh.

These are all the Parts belonging to the Reins; and as their Fluid is of no further Service

Its Situation and Shape.

Why the Kidneys are placed so near the Heart.



Their use.

Service to the Body, it hath this reservatory made on purpose for it, which the other Glands of the Body need not, except the Gall-Bladder, there being a continual occasion or need of their Juices. The use of the Kidneys then, any Body may know, is, to separate the Urine from the Blood, which by the Motion of the Heart and Arteries is thrust into them, and so conveyed to the Bladder, the Blood, which could not for the bigness of its parts, returning back by the Emulgent Veins. And for this Reason they are appointed so near the Heart, that they may receive the Blood when hottest and freest to part with its *Serum*; and where, by the by, we may see the direct contrary Order used here, to what is in those Glands that secrete a thick Fluid.

Why the Kidneys so near the Heart.

This Position of the Kidneys so near to the Heart is, that the thickest parts of the Blood may not have time to unite with the Serous, and so stop them in their Office, as the Case is sometimes in the breeding of the Stone. Again, this nigh Position occasions a Secretion of a greater Quantity in a given time, than what could have been, had they been placed further from it; for as the Celerity of the Blood is reciprocally, as the distance is from the Heart, so the Secretions are always, as the Velocity of the Blood, at the Orifices of their Ducts, and

confe-

consequently the Quantity secreted, in any given time, must be directly, as the quantity of Blood that passes by those Orifices of the Glands. And for this Reason also it is, that the Emulgent Vessels are so extraordinary large, in proportion to the smallness of the Kidneys, and in comparison of those of other Bowels of the Body, though much greater in Quantity, that the Blood may pass more plentifully thro' them, to have a greater quantity of aqueous Parts separated from it. And the great firmness and solidity of their Substance, is occasioned by nothing else but by this Velocity of the Blood at their Orifices; whereby the proper parts for Nourishment or Secretion are drove or impacted into the *Vacuola*, which receive them, with a greater Force; and from the different Velocities of the said Blood, in the different parts of the Body, proceed all the different Textures thereof.

But some would have Secretion performed by Fermentation, and some by Percolation; the last of which in some respect must be true, considering the Nature of the Glands, which are like so many cylindrical Strainers, and the plain Order of Nature, who affects simplicity in all her Operations. I think no one can deny but that the last is most intelligible, easy and uniform.

How separated.

But as it is the weakness of some Men to be

be too credulous, it is likewise as great a fault in another set of Men to believe nothing at all, and do the World no kindness, but what results from Contradiction: Those I desire to shun, and shall proceed, whatever they think of it, to shew, how Water, which consists of finer parts than those of the Blood, can pass off here, without any of them along with it, taking in here what hath been said of Glandular Secretion in general in a former Chapter; for supposing Urine to be that Fluid, that consists of the smallest Particles of the Blood, and the Renal Glands to be those, which have their Secretory Ducts of the smallest Diameter, it will then follow, that the smallest Particles can only enter, and that all others must pass by and return back by the Veins, whilst the Fluid, that passes out at the other Extremity of the Gland, called the *Excretory Duct*, will be such as is required.

The Glands  
of the Kid-  
neys, why  
small.

To illustrate this Subject still a little further, it is here necessary, that the Glands of the Kidneys should be the smallest of any, except those of the Brain. It is likewise necessary, that their evanescent Arteries should not have so many Complications and Convolution as those of other Glands; that the *Serum*, as soon as separated, may be directly carried off: From all which it will necessarily follow, that they will easily admit the *Serum*, and permit no larger Particles to pass off by this Secretion.

But



But then, says one, as these secretory Ducts pass from the Sides of the Extremities of their Arteries at right angles, how can any Liquor pass that way, which is so directly against the straight Motion of the Blood's Circulation? This is performed by the Force of the Heart, though the Effect is in another Direction different from that of the Blood's Motion; and may easily be conceived, if we consider again, that it is the Property of all Glands to press *Undequaque*; wherefore the Pressure of a contained Fluid, will be in a Direction perpendicular to the Sides of the containing Vessel: To which, adding the Motion or Force of the Heart upon the Column of Blood in the great Artery, which makes it more in a Direction parallel to the Axis of the Vessels; we have a compound Motion, which, both acting together, will force the Fluid into the secretory Ducts in a Direction perpendicular to the Trunk of their Artery.

A little above the Kidneys there lie two little flattish Bodies, called the *Glandulæ Renales*, wrap'd up in Fat, about the bigness of a Nux Vomica, the right One exceeding the Left in bigness. They are covered with a fine Membrane, by which they are strongly fastened to the external one of the Kidneys. They are almost as big as the Kidneys themselves in a *Fœ-*

The Glandulæ Renales described.

*tus*, and Children till almost half a Year old; but afterwards grow but very slowly, and when the Privities begin to have Hair, cease growing any more.

Their Substance is hollow, containing a blackish Sort of Liquor. They receive an Artery from the Emulgent, and sometimes from the Aorta, and their Nerves from the Intercostal Pair.

*Their Use.* As to their Use it is not yet well known; but so far, I think, is evident, that they, as well as the Gut Cæcum, the Gland Thymus and Umbelical Vessels, were designed chiefly for the *Fætus* before Birth; and therefore are in them so remarkably large. Some, as *Vesalius*, believe that they secrete that thick Matter found in them, to serve as a Rennet to provoke the Secretion of Serum from the Blood: But this Use can never hold with the Manner of Secretion in other Parts, nor will the present State of Anatomy admit of any other way; besides, they have no Communication with the Emulgent Vessels.

Others think they serve as a Receptacle for the Blood that flows to the Kidneys thereby preventing too large a Secretion of Urine, that the *Fætus* may be able to hold it all in the Bladder till after Birth. Whilst others again think they separate the Liquor from the Arterial Blood like a kind of Sapo to dilute the returning Blood that

is too thick after it comes from the Kidneys, which indeed is the most likely. But not to mention the most simple Opinions of *Spigelius*, *Riolanus*, *Glisson* and *Wharton* about them, we must even acquiesce in our Ignorance till time discovers them better to us.

To these we may add the *Lachrymal* Of the Lachrymal Glands. Glands, in as much as they secrete a

watry Fluid resembling Urine, which occasions the common saying, the more any cry the less they piss. These come not under any particular Head, being but small, and in respect of their Size inconsiderable Parts. They are situated on the backside of the Conjunctiva, upon the upper Part of the Globe of the Eye, pretty large, divided into several Lobes, each of which sends out an excretory Channel, which opens in the foreside of this Membrane, where it covers the upper Lid. They separate the Matter of Tears, and keep the Eye always moist, to defend it from the Injuries of the drying Air; from whence the Liquor runs along the under eye-lid into the *Puncta Lachrymalia*, which are two little holes in the great Canthus, which discharge it into a small membranous Bag, that sends out from its bottom, a small Tube which pierces the Nose, and opens under the upper Lamina of the Os Spongiosum, and serves also to moisten



moisten the inner Membrane of the Nostrils. Upon the two foresaid Punctures there is a Caruncle on each to keep them always open, when the Eye is shut, which were formerly thought to be Lachrymal Glands, whereas they are now found to lie on the other side, or lesser Canthus of the Eye. Upon Grief of Mind, attended with strong Actions of the neighbouring Muscles, they make large Secretions, occasioned by the new impressed Velocity of the Blood upon those Contractions which we call weeping; and in some People amounts to a very considerable Quantity in a short time; and does not flow from the Brain as the Antients thought.

These are all the most principal Glands that are directly necessary towards the Health or well being of every individual Body. But yet there are many more, that do not come under any particular Head, as being dispersed here and there over the whole Body, which all amount to thirty seven Sorts, which all separate different Fluids from the same Mass of Blood, caused, as I have said, from their different Diameters, Distances from the Heart and different Angles they make to the Trunk of their Arteries; upon which Head the whole Doctrine of animal Secretion does depend, the Knowledge

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which is necessary to a Physician, who makes Cures his Intention and Aim.

It follows next, in Place and Order, to treat of those Glands belonging to Generation; for as we are not made wholly for our selves, but also for our Posterity, Nature hath furnished our Bodies with more Parts, than what are barely necessary for our own Existence, and without which we should only answer half the End and Design of our Being; and first of those belonging to the Male, as being the superior of both Sexes.

CHAP. XVI.

*Of the* TESTICLES.

THE *Testicles* are two glandular Bodies, and the proper Vessels of the Secretion of the male Sperm; whose structure also is very nice and wonderful, and have also three Coats or Coverings, the Scrotum, the Vaginalis and Albuginea. They arise from the Aorta before it divides into the Iliack Branches, a little below the Emulgents, with a very small origin, and dilate and grow larger, as they go forwards, passing down as low as the Scrotum, without the Cavity of the abdomen, where they divide each into

two Branches, the main one making the Substance of their Body, and the other is spent upon the Epididymes.

The Testicles why placed without the Cavity of the Abdomen.

Thus, their Substance is not Marrow, as was formerly thought, but secretory Vessels arising from the Extremities of their Arteries, which secrete the most viscid Fluid from the Blood, by reason their compounding Arteries are most complicated. And for this Reason it is that they are situated out of the Body, at such a distance from the Heart, and with such narrow Orifices, and which grow larger afterwards; all which Circumstances, I say, are to check the Velocity of the Blood, and to give it Time and Opportunity to form those larger sized Particles of which the Seed consists: for that the Viscidity of a Fluid separated will be reciprocally as the Celerity of the Blood, at the Orifice of the separating Canal, therefore Nature hath placed them on the Outside of the Cavity; which is not so in Fowls, by reason they would be often in Danger, and likewise it would incommode their Flying.

Their Substance, I say, is nothing but the foldings of several small Tubes, disposed in such a Manner, that if you put them in Water, after having stript them of their Tunicle, by stirring a little the fixed Vessels themselves, without the Help of Instruments, they will separate one from another,



as to be drawn out a very great Length. They run in very short Reathes from the Tunica Albuginea to the Axis of the Testicles, having Partitions from one another, by thin membranous Productions from their investing Parts, which unite all at the Axis, and form a Cover for some small Tubes, which at one End unite, and terminate in one Canal ; which again, by several Turnings and Windings upon the upper Surface of the Testicle, constitute the excretory Duct of the former called Epididymes, which being continued, and ascending from the Extremity, form the defferrent Vessels, one from each, about the Bigness of a Goose Quill, which, passing up to the hinder Part of the Neck of the Bladder, empty themselves into their proper Receptacle or Cistern, as all other excretory Ducts do, which are called the seminal Bladders, made of an Expansion of these, through which they pass at last, very near each other ; and growing smaller and smaller, they pass through the Prostratæ, and open into the Urethra, a little below the Neck of the Bladder, where each Orifice or Perforation hath a spongy Border, to prevent the involuntary Emission of the Semen, called the *Caput Galinaginis*.

This is a general View of the internal Parts of Generation in Men, the particu-

lar Observables of which are these ; the narrow Orifices of their Arteries at their Origin, the Largeness of their Veins, the Traces and Wreaths of their secretory Ducts, from the Albuginous Coat to the Axis of the Testicles, as so many *Radii* from the Circumference to the Centre ; and all conducing to the due Formation of the Semen : For those Particles which compose it, being gross, and Particles of large Surfaces, all the smaller Parts of the Blood must needs enter the Tubes with them : therefore, that none but the former might arrive at their excretory Ducts or deferrent Vessels, it is necessary that the secretory Ducts of the Testicles should be long, that many smaller Branches might proceed from them, to carry off the smaller Particles, not needful to compose the Matter of the Semen : Wherefore it is that there are so many Lymphaticks belonging to them, which discharge themselves into the inguinal Glands, in order to pass on to the Receptacle of Chyle. The greater Length of the *Vasa deferentia* is also observable, to prevent the Impetus of the Seed ; being capable of dilating their Orifices at the Extremities, so as to emit the Semen with the Assistance of the Compression of the surrounding Parts in Copulation.

And

And here we may carry on our wonted Analogy; for we find here also, that an Artery continued with some small Difference in its Complication, constitutes these glandulous Bodies the Testicles, and all Parts belonging to them, with the *Vasa deferentia*, which being enlarged at one End form the *Vesiculæ seminales*, as the Bladder is from the Ureters. In all which there is a general Mechanism common with all the other Parts and Viscera of the Body; their particular Differences arising chiefly from their different Magnitudes, Situations, Thickness and Lengths, with the different Velocities and Quantities of the Blood that flows to them, for their several Secretions and Uses.

Their Figure is somewhat like that of an Hen's Egg, but something flatter on each Side, that being the most capacious Form under the same Magnitude that can be, and the most fit, for all the several Traces of the secretory Ducts to arise from the Circumference, without pressing upon or crossing of one another. The Right is often bigger than the Left, and for the same Reason that the Limbs on the right Side exceed the left in Strength, the Velocity and Quantity of Blood being in the one greater than in the other: Wherefore we are stronger on the right Side than on the left, most commonly using it more

The Testicles why of an Oval Figure: One bigger than the other, and two in Number.



more. And as Accretion is in proportion to the Quantity of Blood and Degree of Motion, it will therefore follow, that the right Side must be nourished something more and quicker than the left, wherefore all the Parts belonging to it must be bigger. They are two in Number, that one may serve, if any Accident should occasion the Loss of the other.

They send off their Veins back to the Cava, the Left of which does not enter it directly as the other, but passes into the left emulgent Vein, to prevent crossing the main Artery, which, by its Pulsation would have stoped its slow Motion through it, occasioned by the Largeness of the one and the Smallness of the other.

The Testicles, as we have said, are well guarded with three Coats or Teguments, the External common to both, called the Scrotum; divided through the Middle with a membranous Partition, to prevent the Twisting of the Testicles and their Friction against one another. It consists of a *Cuticle, Cutis, Membrana adiposa* and *mucular Coats*, but all very thin, to avoid being heavy and troublesome. It serves instead, and is a Production of the common Integument of the Abdomen, to contain and defend the Arteries, and assist their Motions.

The second Coat is the Vaginalis, and which is reckoned a Production of the Peritonæum, but I cannot say how true; for it hath no Connection with it, but rather proceeds from the Membrane of the Abdominal Muscles; for as at a Dissection we were trying to separate and remove all the Viscera whole and entire out of the Abdomen; without opening the Peritonæum, we found there were no such Perforations through it for the Spermatick Vessels to pass to the Testicles, but that they ran along between the Duplicature of the Peritonæum behind, without ever entering the Cavity of the Abdomen, as was formerly thought, and then enter the Holes of the Transverse and Oblique Muscles, where they meet with this Tegument, which closely embraces the whole Body of the Testicles, and adheres to them at their Extremities. The Cremaster Muscles, that arise from the Os pubis, are inserted into this Coat, and pull them upwards when they act, being also assisted by the Corrugation of the Muscular Coat of the Scrotum.

The third and internal Coat is the white Coat, which is very smooth, dense and strong, being an Expansion of the Coats of those Vessels which enter the Testicles; which even enters the very Bodies of them, making that Body that divides

vides the Traces or Wreaths that the secretory Ducts make in them. This Coat serves to keep all close, distinct and warm, that Secretion may go on without Interruption.

Of the  
*Vasa de-*  
*ferentia.*

The next Part to these are the deferent Vessels, which arise from the Extremities of the Former, being their excretory Vessels or Ducts; and ascending upwards the same Way the Spermatick Vessels descend to the Testicles, enter by the Holes in the Muscles into the Abdomen, and marching over them, between the backSide of the Bladder and the Rectum, they grow larger, and then coming closer to each other, they grow very small again, and empty themselves into the Seminal Bladders.

The Seminal Bladders are two in Number, one on each Side, tied to one another, by a communicating Membrane of their *Fibres*; which in Coition serve to contract and compress them. They are about two Fingers Breadth long, and near an Inch broad, resembling the Meanders or Convolutions of the Brain. They grow very narrow at their End which is next to the *Prostratae*. Their Cavities are divided by membranous Cells, which serve to keep the Seed in, like Honey-combs, that all may not be ejected at once, and to assist their Contractions, when expelled; they open



open distinctly by two Orifices into the former Vessels, from which they receive the Seed, to be reserved, till there is occasion for it: Next these is the

*Prostratæ*, which is a large cellulous Gland, covered with a strong muscular Membrane, and situated at the Neck of the Bladder, about the bigness of a Walnut: Having many little Glands, that lie upon the Sides of the Vesicles that separate a mucilaginous Liquor, to be deposited in them, ready for the Lubricating the Urethra upon Ejection, which is carried into the Beginning of the Urethra, by twelve little excretory Ducts, which open about the Orifices of the different Vessels, the Borders of which are all Spongy, to hinder the too quick returning off of this Liquor, as the Case is in foul Embraces, where the venereal Salts, carried hither by the Elasticity of the Air, corrode them and so cause the Gonorrhea.

As to the Use of this Liquor, Authors differ about it; some thinking it of no greater use than to smoothen and lubricate the Urethra, to prevent the great Pain that would otherwise ensue upon Ejection, and to assist the free Motion of the Semen, by removing that Friction, that would often quite stop it, when dry. But some think it adds a greater Perfection to

Of the Use  
of the Pro-  
stratæ.

to the Seed which comes from the Testicles, and renders it more fruitful ; but I think indeed, with *Regner de Graef*, that this Liquor serves only for a Vehicle to the Seed, as it passes from the Vessels to the Matrix ; and perhaps serves there for Nourishment for the Animalcula till conceived. These are the chief Remarkables belonging to the internal Parts of Generation in the Male, what remains we refer to the Chapter of external Parts, they not belonging to the Theory of Glands ; therefore, we shall proceed to view those of the Female, which are mostly glandular too, with some Variation.

## CH A P. XVII.

*Of the OVARIES.*

**A**S a Woman was made for a Help-mate for Man, Nature hath fitly provided her with those Parts or Organs of Generation which the other wants, not allowing him, the Vegetables, to bring forth Seed of himself, but hath qualified her to enamour him to the Female, and her to him, that all Family Duties might go cordially on, to the general Good of the whole Creation, and ful-

fulfilling the wise Intention of Providence.

And here we must observe their great likeness to the Male's Parts, as far as the Nature of things could possibly admit, for supposing his to be inverted into the Cavity of the Abdomen, you have a resembling Idea of the other. But to proceed, the Beginnings of the internal Parts of Generation in Women, are the same as in Men, *viz.* four Spermatick Vessels, two Arteries and two Veins, arising as theirs do, only are shorter, because it would have been inconvenient for the Ovaries to be placed without their Bodies, as the Testicles are in the Male; therefore to make amends for this, they are fuller of Turnings and Windings as they pass down, which retards the Motion of the Blood, all one as if the Ovaries had been placed lower down, both by the greater Lengths of them, as by the many Angles they make with one another.

As soon as the Spermatick Arteries arrive at the Testes or Ovaries of the Female, they each divide into two Branches, the smallest of which is spent upon the Ovaries. They have not many Blood-Vessels, by reason their Secretion is but very small and slow, being not much wanted. The other larger Branch is divided into three more, of which one is bestowed on the Womb,

Of the Spermatick Vessels of the Female.



Womb, another upon the Vagina, and the third upon the Ligaments and the Fallopian Tubes of the Womb. These all have their proper Veins, which return back by the same Courses, and return the Blood into the Aorta again.

Of the Ovaries.

The *Ovaries* are two little Bodies, called by some, the Female Testicles, about half as big as those of a Man, and of the like Figure, situated about two Fingers Breadth distant from the Bottom of the Womb, and fastened by the broad Ligament, adhering to the Peritonæum, at the Ilia, by the Spermatick Vessels, covered with a common Membrane from it, and a proper one from the Coats of its own Vessels, which sticks very close to them, as the Albuginous does to those of the Male.

Their Substance is of a very particular Kind, as their Use is too, consisting of Fibres and Membranes, that have many Spaces or Interstices between, like so many Cells of a Honey Comb, in which are found several little Bladders full of a clear Liquor, which when boiled, turns to a white solid Substance like the White of an Egg. Those Ovaries serve then as proper Beds and Repositories for those little Bladders, till there is occasion for their further Use, and were first discovered by *John Van Horn*, an Anatomist, at *Leyden*,

about

about the Year 1668, and further improved, by *Regner de Graef*, who was Pupil to *Sylvius*, and a Physician at *Delph*, who being snatched off by sudden Death, left the further Discoveries to be performed by *John Swammerdam*, Physician at *Amsterdam*.

These little Bladders, that lodge in the former, are true and real Eggs, which serve as the proper Nidus for the Animal-  
The Mechanism and Use of the Female Eggs.  
 cula of the Male at Conception, and are of different Size and Number in Women of different Ages, being sometimes ten or twenty in each Ovary. They likewise have three fine Membranes or Coats, from the three abovesaid Coats of their secretory Ducts, which arise from their Artery, and in time manifestly show themselves, and form those Parts of the Birth called the Enclosures or Secundines; and as one part of the Body is but a Continuation of the other, arising all from the Heart, and being all entire, though in Miniature, in the Stamen before Conception, it is not so hard a Matter to conceive of the Animal Oeconomy as it is by some thought to be. So we see, that these very Eggs, as well as the Ovaries they lodge in, are but the Continuation of the finest of the Coats of their Excretory Ducts, by the flowing in of this said clear Liquor, which is secreted by the said Duct, and here deposited

posited for future Use; where it cannot pass out, at the further Side of the Bladder, being a whole concave Sphere, but only at its Orifice, where the Duct enters; and therefore, when filled so full that it can hold no more, the Distension of this Bladder closes up the Duct that fed it, and is then in that State, which we call ripe. But more of this, with a full Account of the Mode of Generation, or Conception, we refer to the Chapter of their Fluids.

A farther  
Confide-  
ration of  
Hen's  
Eggs.

In Cows, after Conception, the Hole may be seen, from which the Egg fell, and, in a few Days, becomes like a Cicatrix; from which, without farther Argument, it is plain, that all Animals have Eggs; which are nothing else, as we said before, but those little Bladders contained in their Testicles, which, as soon as they are impregnated, do presently slide into the Matrix, there to be nourished till fit to bear the Air. And that these Eggs owe not their Origin in the least to the Seed of the Male, is plain, from their prior Existence before the Use of any for even, as soon as born, they may all be seen in Clusters (in young Chickens as soon as hatched) and in larger Creatures when young, though impossible in some without the Help of a Microscope, as a famous Author observes. Now whether those Vessels do immediately shed this Lymph

Vid. Har-  
vey, Ex-  
ercitat. 3.  
P. 10.



Lymph into those little Bladders, or mediately by the Help of certain little Glands, that lye hid in the *fibrous Texture* of the Membranes of the *Ovarium* for the Secretion of it, is hard to determine; though, according to the usual Custom of Nature, in all other Glands of the Body, the last is most consonant; and then, we will call the Ducts that feed these Bladders, the excretory Ducts of those Glands; and so we carry one uniform Theory and Order through our whole animal Oeconomy.

They are two in Number, lest one should meet with any Misfortune; and to cause the more Conceptions; some being ripe in one, when none are in the other; and not single, as in Hens, that lay but for a short Time and often.

Next to these are the Tubes of the Womb, found out by *Fallopious* from whom they have their Name. They are situated one on the right Side, and the other on the left, running from the Sides of its Bottom, with narrow Beginnings, which dilate in the Form of a Trumpet to their Extremities, where they are contracted again into a small Orifice, like the Mouth of a Purse, from whose Circumference, they dilate into a pretty broad Membrane called *Morsus Diaboli*, because it looks as if tore at the Edges. The Capacity next the Womb will scarce admit of

Of the Mechanism of the Fallopian Tubes.

a Hog's Bristle, but, at its widest Part, will take in the End of one's little Finger. Their Substance consists of the same with that of the Womb, they being only productions from it, about four or five Fingers Breadth long; and serve for the conveying of the Animalcula to, and the Eggs from the Ovaria to the Womb, the Mechanism of which is very suitable for it, the ragged Expansion of its Membrane serving to catch the Egg, as it falls, that it may not drop aside into the Cavity of the Abdomen, which at that Time, though not at others, is turned upwards to the Ovary, by the Distension of its Fibres with Blood and nervous Juice, which makes its Extremity form a greater Curve with the other than before, whereby the Egg, dropping perpendicularly, may fall exactly into its Mouth or Orifice, where it is detained in the widest Part of it for some Days, till the outward Orifice of the Womb is well shut; wherefore the Orifice of this Tube is so very small next the Womb, to prevent the Air injuring the Egg; but at last lets it pass through it being forced upon it, by the Distension occasioned by the Growing of that Egg whilst in the Tube, even as it afterwards forces upon the other Orifice of the Womb, at the Birth.

Under those lyes the Matrix or Womb  
about

## Of the OVARIES.

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about two Fingers Breadth, and one and a half thick, and three long, in Figure like a Pear, and its Cavity in Maids large enough to contain an Almond. Its Substance is cellulous, consisting of three Membranes, as all the other Parts do, upon the Internal of which there are many Glands, which separate a Liquor to lubricate its Cavity. Its lower Extremity joins the upper End of the Vagina, where it makes a little Protuberance resembling the Muzzle of a Dog, called the *Os Tineæ*, well lined with Glands, which separate a Liquor or Substance like Birdlime, to seal up its Orifice close in the Time of Gestation, and which are the Seat of the *Fluor Albus* or that Distemper called the Whites. All its Vessels creep upon it, with many Turnings and Windings, that they may not break, when much distended. It is tied by the broad and round Ligaments, to keep it firm and steady; the first going out from its Sides like a Pair of Wings, being only a Production of the Peritonæum; the round ones pass round the Bottom of it like a Hood, and proceed down through the Rings of the oblique and transverse Muscles of the Abdomen to the *Os pubis*, where they expand like a Goose's Foot, and are partly inserted into the *Os pubis* and partly into the membranous Muscle of the Thigh, on the upper Part of the Inside of

A farther  
Description  
of the  
Remarkable  
of the  
Womb.



it ; from whence proceed the Pains that Women feel when big with Child in those Parts.

## CHAP. XVIII.

*Of the MEMBRANES.*

**H**AVING thus spoke of every glandular Bowel in the Body particularly by themselves, we shall next, to render our animal View more perfect and entire, proceed to treat of these many membranous Expansions, which every where offer themselves to our Consideration, and to prevent any Interruption they would have caused in the Description of the former. I thought therefore fit to put them all down here together, and make them introductory to the Chapter of Bones.

Mem-  
branes  
what.

Membranes then are so many thin Skins or Webs, of different Fibres variously interwoven with one another, constituting broad, flat Expansions, for Linings and Coverings of all the single Parts of the Body. By means of their Fibres they are very extensible and elastick, whereby they are able to contract and closely grasp the Parts they contain, their nervous Fibres giving them an exquisite Sense of Feeling, which is the Cause of their Contraction.

Their

Their Use is well known to be, to wrap some Parts up in, to suspend others, and to line some. Their differences are many and great; first, in respect of their Substance: Some being thin and some thick; of their Figures, some being broad, some long, and others triangular; in respect of their Situation, some external, some internal: But their chief Differences arise from the different Order, Number, and Bigness of their constituent Fibres, which they are made up of; and so, some are little and some large, some are soft and some hard, according the Uses they are designed for.

The Use  
of the  
Mem-  
branes.

Their Number is almost infinite, but the most considerable are these that follow. In the Head are the Meninges, consisting of the *Dura* and *Pia Mater*. The first is a strong and thick Membrane which covers all the Cavity of the Skull, and contains the whole Brain loosely, and serves as a Lining to guard the Vessels of the Brain that run upon its Surface, and between its own Duplicature, from being too much pressed by the Skull. It adheres very close to the Sutures, by the Fibres and Vessels it sends to the Pericranium, with a Design to keep it steady and hold, from sinking close upon the internal Membrane the *Pia Mater*. It also gives a Coat to all the Membranes of the Body. It is a double Membrane composed and

Of the  
*Dura Ma-*  
*ter*.

made of every strong Fibres. It hath three Proceſſes, made by the Doubling of its inner Membrane. The first forms the Falx; the second, that portion that divides the Cerebrum from the Cerebellum, very strong and thick, that the weight of the one might not offend the other, which lyes under it; and the third separates the external Substance of the Cerebellum into two *protuberances*. In this Membrane likewise are several Sinus's, that run along between its two Linings; four of which are very notable; first, the Longitudinal, which runs along all the Falx, directly under the sagital Suture, into which some of the Blood from the Brain enters, by reason the motion of it in the Veins is but slow there. This Sinus hath several Cells and round Ligaments, which cross from one Side to the other, which serves to push forwards the contained Blood by their Elasticity: The Second and Third which this opens into, are the Lateral; they arise from the End of the Former, and going down upon the Sides of the occipital Bones in a crooked Way, they pass through the same Hole with the eighth Pair of Nerves, and discharge themselves into the internal Jugulars. The Fourth lyes behind, and opens where the lateral Sinus joins the

Lon-



Longitudinal. This Meeting of the four Sinus's is called Torcular.

It is exquisite in feeling, being well stocked with Nerves. The Use of it, as we said before, is, to line the Skull, the Brain, the spinal Marrow, and all the Nerves, to divide the Cerebrum in two, and hinder its pressing upon the Cerebellum, to receive the Blood freely from the Veins of the Brain, and discharge it quickly into the Jugulars; and last of all to cause a Consent and Sympathy amongst the Nerves, when a Plethora of Spirits happens in any of them.

The *Pia Mater* is as thin as the other Of the  
Pia Ma-  
ter. is thick, and also double, lying immediately under the *Dura Mater*, and covers all the Substance of the Brain; for which Reason its inner Membrane is much longer than its outward one, running in between all the Foldings and Circumvolutions of the cortical Part of the Brain, to separate them, and sustain their blood Vessels, which make many Turnings upon it, before they enter the Substance thereof, to break the Impetus of the Blood, that it may not enter too forcibly into the tender Glands, to dilate them too much, as in the Case of Madness.

The Use of this Membrane is the same as of the former, only that this covers not the Nerves in general as the other does, but

but every single Fibre of them in particular.

The  
Mem-  
branes of  
the Eyes.

The next are the Membranes of the Eyes ; which some reckon seven ; the Membrane that lines the Inside of the Nose and its spongy Bones ; the Membrane of the Tympanum and Mouth ; the Tunicle proper to the Tongue and Palate : These, with several lesser ones, are the Membranes belonging to the Head.

Of the  
Thorax.

In the Breast or Thorax are these : First, the Pleura, which is a double Membrane likewise, and lines all the Cavity of the Thorax, which arising from the Vertebrae of the Back, ascends, on each Side, upon the Inside of the Ribs to the Middle of the Sternum or Breast-bone, and is fixed to the Periosteum, and the internal intercostal Muscles, and covers the Midriff. Its Use is to line the Surface of the Ribs, that the Lungs may play easy without friction, and to give a Covering to the Parts there contained. It is the Seat of the Distemper called a Pleurisy, which is an Inflammation of this Part, caused by stagnant Blood. It likewise forms that Partition in the Breast called the Mediastinum, which divides the Thorax into two, containing, in its Duplicature, the Heart in its Pericardium. It serves to suspend the Heart and to part the Communication of the Cavities of the two Lobes of the

the Lungs, that one might officiate if the other should happen to be hindered by a Wound on the other Side.

In the lower Belly is the Peritonæum, Of the Abdomen. which lines the Cavity of the Abdomen, and gives Coverings to all its Parts contained, as the Pleura does to the Cavity of the Thorax. It lyes immediately under the Muscles of the lower Belly, and is a thin and soft Membrane, containing many small Glands in it, which make it very smooth and moist with their Liquor, for the easy Motion of the Intestines, which, when obstructed, as in several Dropsies and other disorders of the Body, makes it grow very thick and hard. The upper Part covers the under Side of the Midriff, as the Pleura did its upper Side, and closely adheres to it, as the fore Side does to the transverse Muscles and the *Linea alba*, and below to the *Os pubis*, and on the back Part to the *Os Sacrum* and *Vertebræ* of the Loins. It is always as well as the other were, and contains, in its Duplication, the umbelical Vessels, the Bladder, Ureters, Kidneys, and spermatick Vessels, giving them all a Covering; besides, as we said before, containing all the Bowels of the Abdomen, and conveying blood Vessels to other Parts; which are the proper Uses of it.

The



Of the  
Mesentery.

The *Mesentery* is the next Membrane of Note in the lower Venter; and is about three Ells in Length, and five Fingers Breadth in Diameter, containing, in every Inch of it, three Inches of the Intestines fastened to it; for it makes a circular Figure, with a narrow Production, to which the End of the Colon, and the Beginning of the Rectum, are fastened, and is it self strongly tied to the three first *Vertebrae* of the Loins. It is composed of three Lamina; two external; one on each Side common, proceeding from the Peritonæum, and the middle one proper to it self, on which are placed many Glands, and also fat. Its Use is to keep the Guts in a little Compass, and to prevent them entangling with one another.

A Description  
of the  
Caul.

The *Omentum* or *Caul* is another Membrane, and lyes on the Inside of the Peritonæum; it is a thin but double Membrane rumpled like a Purse, and covers the greatest Part of the Guts, for whose Service it was designed. It is like a wide empty Bag, with its Mouth tied to the Hollow of the Liver; and, on the left Side, to the Spleen; its upper Part to the Bottom of the Stomach and those Parts, its Bottom or under Part lying loose and fixed to no Part. It is interspersed with a great deal of Fat, which makes it weigh generally half a Pound, and often more. Its Use is to keep

keep the Guts steady and regular, and to grease them gently with its Fat, to facilitate their Motions, and to support the Vessels, which pass from the Spleen to the Stomach and adjacent Parts, and to reflect back the Heat of the Bowels, to warm and cherish the Guts, to promote the better Concoction.

Another Sort of *Membranes* are those of the *Muscles*, being as some think, of two Kinds to all; one common, and the other proper to each; but it is now found, that there is no common Membrane; for that Mistake was made by Apaneurosis of several Muscles which by some was taken to be a common Membrane; whereas upon stricter Observation, there is no such Thing, but only the proper Membranes, which immediately cover all and every one of the Fibres of a Muscle, and is closely tacked to them.

Above these lyes the *Adipose* or fat *Membrane* or rather spongy Lining; it lyes next the Flesh and is nothing but a Net, consisting most of little Cells, with small Glands placed upon them, which separate a Fat or oily Juice from the Blood, and deposit it in these small Cells, which have various Figures; some flat, some oval and some of another Figure, there to be kept safe for Use, which is to keep the Muscles warm and moist, that they may the more freely

Of the Membranes of the Muscles.

Of the Adipose Membrane.

freely move; and also to blunt the Salts in the Blood, by mixing with it again; much of which, we see, is voided with the Urine in hec tick Cases.

Of the Membranes of the Fœtus.

Amongst the Number of *Membranes* we must also reckon those of the *Fœtus*, which are three: The Internal, which immediately surrounds it, called the *Amnios*; which gently rests upon the *Chorion*, which is the external one, yet no where joined to it, but at one small Place, where the Pore is, where they broke off from their excretory Duct, at which the *Animalcule* enters in, at Conception, after it hath fallen from the Ovary, and not before, as we shall afterwards shew.

It is a fine, single, soft and very smooth Membrane, and serves to contain a fine milky Liquor, to nourish the Child with. How it came there, we shall refer the Account to the proper Chapter of Fluids. Around this, sticking to the *Chorion*, is another Membrane called the *Alantoid* or Urinary one, first found out by *Needham*, and serves to collect and retain the Urine of the *Fœtus* till Delivery. It resembles a long Gut, which surrounds the *Amnios* like a Pudding in Brutes, into which the *Urachus* empties the Urine, by the Means of the Navel-string. In human Bodies (and some other Animals) it is round, because that Form gives less

pain



tain to the Mother. Those who will not believe the Existence of this Membrane, as there are some who still deny it, may be fully convinced by Dr. *Halem*, his Description of it in the *Philosophical Transactions*. Vid. Philosophical Transactions, New 271.

The Chorion is the largest and exterior Membrane that encloses the *Fætus*, and is thick and rough without; the better to adhere to the Womb. To this the Placenta is fixed; which is no more than a Texture of Veins and Arteries, whose Extremities open into the Sides of the hypogastrick Vessels of the Mother, to receive Blood from her, to carry on the Circulation of the Juice in the tender Body of the *Fætus*. It takes its Origin from the Vein and Arteries of the Navel-string, which divide into infinite many Branches, after it hath passed out at that Pore, where it self entered, and the last, by insinuating into the Pores of the Mother's Womb, receives first a fine Fluid from thence, and afterwards Blood, as we shall show in our second Part. Whence we see, that these Membranes are but three Membranes of the Egg, which existed *ab origine* in the Ovary of the Female, before herself was born; and are no more than the Continuation and new Modification of the three Coats of the Arteries, from which all Parts take their Substance:

stance: But the Navel-string takes its Origin from the *Animalcule*, which it brought along with it from the Father, when entering the Egg at the Pore, where it broke from its excretory Duct, sending out the umbelical Vessels at the same, to be spread on the outward Surface of the Chorion, to communicate with the Vessels of the Mother.

Of the  
Periofte-  
um and  
Pericrani-  
um.

But to return to the Membranes of the Body. We shall next take notice of the *Periofteum*. It is a very thin and nervous Membrane, of an exquisite Sense, immediately covering all the Bones except the Teeth. That Part of it that covers the Skull is called the *Pericranium*, and is no distinct Membrane from the other, as the Antients thought, being led into that Mistake by taking the tendinous Part of the occipital and frontal Muscles to be the *Periofteum*, and the true *Periofteum* to be a Membrane distinct and proper to the Skull.

To conclude this Chapter, we shall pass by the Cuticle and Cutis, reserving them to their proper Place, and observe in general, that all Membranes, from their constituent Fibres, have a very elastick Property, which makes them so hard to cure when wounded. We are also to observe, that they have all many fine Glands on their Surface, for the Secretion

of a Liquor, for the free Motion of those Parts which lie next to them; and have Arteries, Veins and Nerves from those Parts that are most adjacent to them. And besides these, there are an infinite Number of small and thin ones more, which have no Names, and come not under our Observation. In short the Frame of our whole Body is made up of nothing else than Membranes differently turned, some crooked and curved, some arched, and some plain: All which themselves, are made up of Fibres which are the first Principles or Materia of our most noble Structure.

## CHAP. XIX.

*Of the BONES.*

BEfore we treat of the other membranous Coverings of the Body, as the *Cutis* and *Cuticula*, we shall next proceed to give an Account of the Bones, which afford, and lay the Foundation both of strength and Shape to the Animal, and afford stabilitment to all and each its parts; serving also for the Insertion and situation of all the Muscles, without which we should be at the best, but a heap of motionless Matter, and our Lives

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an intolerable Burthen to us, if it could be so, and we were capable of subsisting without them. We shall examine, according to our usual Method, into their Nature and Substance in general, and then touch a little on them singly by themselves; where we shall meet with several curious Observations and wonderful Contrivances and Designs, which loudly bespeak a supreme Power, who caused them to grow in the Womb of her that is with Child, and hath each Fibre of them written in his Book.

Of the  
Nature of  
Bones and  
their Origin.

The *Bones* are the hardest, whitest and smoothest Part of the Body, and derive that Condition from a cartilaginous Substance, which also was membranous at the first. It was thought before the Doctrine of *Animalcula* was discovered, that the Bones were formed in the Womb, of the most tartarous and earthy Parts of the Seed; but since then we are certain, there is not such Thing, as the different Parts of the Body arising or proceeding from the different Parts of the Seed; nor one Part exist or formed before another, but they all have their distinct Beginning or Origin from the Stamen of that Animal, though for Distinction's sake in our Description we trace them according to their Continuation and Usefulness in an animal Body, which let it be how it will, the Bones

consequently must have there Beginning there too. So that all that we have to do in this Case then is, to find out their Nature and Texture of Parts, and then their Uses, which is all the Knowledge we can arrive at in such natural Enquiries, leaving the prime Cause to him that made them at the first.

The *Bones* are a Compages of many Membranes, which mutually lie upon one another, like so many Lamina or thin Plates, between whose Spaces are Vessels to carry their own Liquid, and are united by smaller Fibres which transect the other, thereby making a Reticular or Net-work with them, resembling somewhat in Texture that of the Muscles.

All the Bones in the *Fœtus* are first soft and membranous, and then undergo several Alterations in the different Times of Gestation, 'till, at the Age of Maturity, they become hard, white and solid, by their Fibres growing closer to one another, by the Apposition of nutritious Juice which fills up their Pores, by which the Passages of several of the Blood Vessels are closed up, and their farther Growth prevented. The first Alteration that these Membranes undergo, may be seen upon the various Heads of Embryos, where at first there arises a Kind of cartilaginous mass, round which Point are diverging

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thick

thick Strata or Strowings of compressed and compressing Vessels, whose intermediate Parts remain loose and unrestrained; and thus a Bone is made up of a continued Series of these dried and indurated Lamellæ which yet have their proper Fluids passing through them, for their due Nourishment; and which, upon Fractures, issue out between the Extremities of the divided Bone, and form that irregular Part called a Callous.

In what Part of the Bone it first begins.

The Part of a Bone which this Point is always seen in, and that ossifies first, is generally in the very Centre of it, for there Dr. *Havers* hath demonstrated the greatest Artery, and consequently the greatest Pulse lies there, which is the chief Cause of its Compression and Ossifying. This being begun it follows, that by their nutritious Juices filling up their Interstices, those Strata will be compressed more and more till they become harder than a Cartilage, and most compact as a Bone; which will still continue growing for twenty Years or more, till at the last many of the Perforations, which before admitted Blood Vessels, are grown together, and the Blood being prevented any longer passing that Way, they lose their former Quantity of Nourishment and consequently continue in one State of Condition without farther Growth; and



so Ossification is performed, as we said, first in a white Spot, with a cartilaginous Margin, and after three or four Months, as Dr. *Boerhave* says, looks like a Star, and sends forth on every Side some Rays, which proceed as far as the Epiphyses. See *Boerhave's* Method of studying Physick, P. 169.

And thus we see, the Substance of the Bones themselves is made up of Fibres, which Fibres make Membranes, which Membranes being laid upon one another, make Cartilages, which closely compacted make Bones. And thus we have the Substance, Texture, the Nature and Manner of Ossification all in one View.

Moreover the Bones are hollow, not only to contain and preserve the Marrow, but also that they might be lighter, and more apt for Motion. They are more compact in the Middle, and spongy near the Extremities; because, in the Middle, the Fibres are much closer compressed; and for no less Design, than for their greater Strength, which would not have been so much, were their Shape otherwise: Therefore all their Lamina do not run from one End of them to the other, but only a few of the most External, whilst, as the great *Monro* says, about the middle Length of the Bone, the innermost gradually separating from the other without, are inclined towards the Axis of it, and form the Cancelli or Lettice-work, Vid. *Monro's* Anatomy of Human Bones.

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which

which is to be seen within most part of the Bones.

I shall pass by speaking of the transverse and longitudinal Fibres of the Bones; of their Sulci and Furrows, of their Veins, Arteries, and Nerves; and of their Cavities and Diseases; and refer the Reader to that excellent Author on those Heads, where they are, with every Part of this Subject, nicely handled in a very concise, comprehensive, and intelligible Manner.

I shall therefore proceed to represent, Lastly, That besides the main Bones themselves, there are other little ones that grow at their Extremities, called the Epiphyses, and serve for great and notable Uses, as first, to unite the Parts firmer together, and for the more convenient Origin of the Muscles and the Insertion of Tendons, that their Directions may be moved farther from the Centre of Motion in the Joints, and so have much greater Power than if they were only to act *in Place*. They are covered with Cartilage for their more easy Motion, and never become Bones, unless in very old Age, because they are always kept moist with Liquor compounded of marrowy Oil from the Cavity of the Bone to which they belong, and a mucilaginous Liquor from the Glands of the Joints which

which being mixed together by the Motion of the Parts, lubricate the Joints without too quick Exhalation, which any other Fluid would be subject to. Again, another Use they serve for, is, to prevent the Fibres of the Bones from growing irregular at their Extremities, therefore they shoot into these Linings or Cases, and are by that Means kept even and regular.

The Inside of the Bones is lined with a fine *Periosteum* as well as their outside, which, according to *Havers*, takes its Origin from the muscular Coat of the medullary Artery, and produces many little Membranes, which, crossing the Cavities, and communicating with one another, form the little Cells or Baggs that contain the Marrow, which is secreted into them from the Blood, which is brought to them by their Arteries, and separated by their small Glands, which are situated there for that Purpose.

Vid. *Havers's Osteology*,  
Nov. Dis.  
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This being the Case of Bones in general, we shall now run over the more Remarkables belonging to them in particular, being in all, the Number of 245, as some reckon; viz. Sixty one belonging to the Head, Sixty four to the Trunk, Sixty to the superior Limbs, and Sixty to the inferior Limbs of the Body, besides the sesamoid Bones, which are said to amount to the Number of Forty eight



more. The first are the Bones of the Skull, which is made up of several small ones; which form a Case or Box, to contain and guard the Brain from external Injuries. It is a little flattish or depressed on its Sides, which is the most convenient Figure, for the Enlargement of the Sight and Hearing; by their meeting with each other they form the Sutures: And for their closer Union, Nature hath not tipped their Edges with a Cartilage, like unto the other Bones, but left them free to their own Irregularities, which proves here very advantagious, by occasioning the Adhesion by their Indentation to be so much the stronger, and which causes their Figure, like the Teeth of Saws that enter one another.

The proper Bones of the Skull are, the *Os Frontis*, *Occipitis*, *Parietalia*, and *Temporūm*, of different Bigness, Curvature and Thickness, as their particular Places and Uses differently require; an exact Description of which would make a Volume alone, and is already completely done to our Hands in *Havers's* and *Monro's* curious Books of Osteology, and therefore shall only touch upon them by the way, as I account for the peculiar Structure and Mechanism of the Parts.

Now the chief Reason, besides other less Advantages, why the Skull is not all

one

one smooth continued Case or Piece, but consists of several, is, because it could not have been ossified soon enough for Birth, and but then very unequal and irregular; and so the Child would have come into the World with too much of it Membranous, the Inconveniency of which need not be told. Therefore, Nature hath appointed eight several Pieces, all which beginning, as all other Bones do, to ossify in the Middle, they meet one another's osseous Fibres, and so frame the Skull firm and strong in every Part, capable to bear the Alteration it suffers after Birth. Another Advantage, which is accidental, is to prevent a Fracture of one Part, from extending beyond the Sutures.

These Bones consist of two Lamina; betwixt lies a cellulous Substance, called the Diploe or Meditullium, made by the bony Fibres of each, crossing the Cavity, and contains a bloody Marrow, to prevent their drying, or too quick Cessation in Growth. The Occipital Bone hath oftentimes several little triangular ones in its Substance, and for the like Purpose, as we said of all of them, because of the great Necessity there is for this Part of the Brain being strongly defended betimes; wherefore this Bone, by this Contrivance is made to ossify very quickly, which without them it could not do. As to their Processes,

Processes, Holes, Sinus's, and Conjunction, I refer the Reader to every Book of Anatomy for them, not being willing here, to repeat more than what is for my Purpose, as they are already so common in every Author.

Of the  
Bones of  
the Face  
and Ears.

The next are the Bones of the Face, as the *Ethmoid* and the *Sphenoid*, which last is the biggest of any; and some Part or other of it, touches all the Rest, as they lie round it. Then there are the eights little Bones of the Ears, which are as big in Children as in Adults, because their Magnitude is not necessary for hearing, and therefore they grow no larger, than to be able to undulate the Air in the Cavity, and yield to the Motion of the Tympanum, which if larger, they would not do. They are four in each Ear, called, the Malleus or Hammer, the Incus or Anvil, the Stapes or Stirrup-like one, and the Orbicular or Round one, which is so very small, that one would think insignificant. The Ethmoid Bone lies above the Nose, and hath a small Process, called, *Crista Galli*, and serves as a fastening for the End of the Falx. This Bone is perforated for the Olfactory Nerves to pass through to the spongy Bones, which lie directly under it. They lead to the Nose, which is made up of two small Bones, to which are joined the Unguis, Vomer, and

then



then the Os Palati and the Bones of the Cheeks and upper Jaw, with the sixteen superior Teeth contained in it. To which we may add, the Bone of the under Jaw, which in us is much rounder than in other Animals, both for the Decency of the Face, and because we are not voracious as they are. This also hath sixteen Teeth in its Sinus's, which answer to the former, and which together with the Os Hyoides makes the Number of Sixty one Bones of the Head; It is called so from the Resemblance it hath to the *Greek* Letter *υ*, and differs from other Bones in its not being articulated with any other, but moves with the Connection it hath with the Muscles and Ligaments of those Parts; its Use is to serve as a solid Lever, to move the Larynx and Fauces with, when its Muscles act upon it.

The Bones of the Trunk are the thirty *Vertebræ*, the Ribs, the Breast-bone, and *Ossa innominata*, with the Scapulæ, two Clavicles, and the three of the *Coccygis*.

The Spine is a long Congeries of Bones, reaching from the first *Vertebra* of the Neck to the Extremity of the Rump, and is remarkable for the several Curvatures it makes, as it passes down, making one forwards behind the Gullet, to support it and the Vessels of the Head; then another

ther backwards to make room for the Heart and Lungs in the Thorax ; then it bends forwards again to support the Viscera of the Abdomen, and last of all it bends outwards again to make room for the Pelvis, and then at its Extremity, it is reflected again to sustain the last great Gut, and yet for all these crooked Turns, as the judicious *Monro* observes, it is so contrived, that it sustains the Centre of Gravity of all the Parts, and not any considerable Weight falls on the Middle of the common Basis. The Structure of the Spine is very Mechanical, and the best that could be contrived ; for it is not made of one continued Bone, for that would wholly have hindered our bending ; but is thus made of many small ones for our better Conveniency in moving, and to do no Damage to the Spinal Marrow ; for were the *Vertebræ* large, they would be apt to press upon it, by making too acute Angles in bending ; but as the Case is, there is something gained from a streight Line in every one to bend the Body, and yet to make no one Angle large enough to do hurt ; so that the Spinal Marrow lies as safe as if contained in an inflexible Case. Something like the Nature of this you may see, by drawing a multangular Figure, where the smaller and smaller you make the Sides thereof, and the more you encrease

increase the Number of Angles; the nearer it will approach to a Circle; therefore, that the *Vertebræ* should make such minute Angles, it was necessary they should be very small; and not only so, but that they should be fastened to each other, by intervening Cartilages, which gives them, by their Elasticity, some greater Degree of Motion, and keeps them from being dislocated, and also hinders them from wearing one another too much, by their mutual Friction. They have all several Perforations for Blood-Vessels and Nerves to pass through, but with some small Variation, according to their different Situations and Uses for which they serve: An Account of which is as followeth.

Those of the Neck are seven, and are all, except the first, near of an equal Bulk, their Uses being near much alike, serving for the Support of the Head, the bending of the Neck, and the Origin and Insertion of Muscles belonging to it. They are flattened on their fore-side for the Gullet, and the Motion of the Superincumbent Muscles. The first of them is called the Atlas, from its Use of supporting the globular Head. It hath no Body as the Rest have, but a long Arch which is joined to the Bone of the Occiput, and is moved along with it, on the other which is called the Dentata, from the Tooth like Processes

Of the  
Vertebræ  
of the  
Neck.



cess on the the superior Part of its Body, which enters the posterior Part of the Arch of the former, which is of a concave Figure on purpose to receive it, and is covered with a strong Ligament, to prevent its hurting the spinal Marrow. The first hath no acute Processes, because, they would be troublesome to the *Musculi Recti* to act on them; but its transverse ones are larger and longer than any of those of the rest, the better to serve for the Origin and Insertion of several Muscles. The second *Vertebra* is that upon which the Head and the first turns, the Shape of it is somewhat Pyramidal, for the securer Articulation of it with the third, or that under it, where it enters into a Hollowness or Cavity below, its upper Part sending off the Toothlike Process to be inserted into the said Arch of the former. It is covered with a Cartilage for its free Motion, and its Point sends off a Ligament to fasten it to the Occiput, to secure it from Dislocation, which, if it at any Time happens, is present Death. The third *Vertebra* of the Neck, is called Axis, and is all alike with the other four, and they have no particular Names, but in general have these Properties belonging to them; their spinal Processes being biforked, for the more convenient Origin and Insertion of those small Muscles; they have like-

wife

wife a Perforation through their transverse Processes, for the secure Passage of the cervical Arteries into the Skull; they are also smaller and harder than the others, that the Neck may be lighter and easier bended, and the spinal Marrow well defended, there not being so great Security for it, otherwise, as there is for it in the former ones.

The *Vertebræ* of the Back are twelve, and are thicker and larger than the former, that they may afford a stronger Basis, for the circumincumbent Weight, and a more convenient Origin and Insertion for the many Muscles thereunto belonging. They are more Convex before than the former, and flattened on their Sides, for the Articulation of the Ribs; their spinal Processes are acute, and slant downwards upon one another, being fastened together with Ligaments, to prevent their too great Motion, to damage the Heart and Lungs in the Thorax. In their transverse Processes, there are Sinus's, to receive the round Tubercles at the Extremities of the Ribs, which, by their Pressure, turns them obliquely backwards. The oblique Processes are placed almost perpendicular, the Superior slanting very little forwards, and the Inferior as much back; all which, by their Position in respect of one another, afford fit Places for the Muscles to arise from,

Of the  
Vertebræ  
of the  
Back.

from, and fortify and strengthen the Frame of the Spine, that it may be able to support its Weight, and bear its many Motions, without the least incommoding the spinal Marrow or prejudicing the Current of the Nerves; and lastly, their Surfaces are not hollow, as those of the Neck, to admit the Superior into them, but are all plain and horizontal, being lined with strong Ligaments betwixt them, which in Time become bony, if what *Fallopious* says be true.

Of the  
Vertebræ  
of the  
Loins.

The *Vertebræ* of the *Loins* are five, and much larger than the former, by reason the main Stress of the Parts rest chiefly upon them. They are of a circular Form and spongy, and at a large Distance from each other, by the extraordinary Thickness of their intervening Cartilages, that they may be fitter for a large Motion. Their spinal Processes are not acute like the former, but very blunt and stand out from the Body of the *Vertebræ* in an horizontal Position; they are very strong and streight, that the Muscles may act upon them more powerfully, and so likewise are the transverse ones for the same Reason, and that they might be some small Defence and Support to the Bowels and Muscles of the Abdomen. The Holes for the Passage of the Nerves, in all these, are each of them common to two *Vertebræ*, being



being formed by both, only the Notch of the Superior is deepest, and that in the inferior *Vertebra* is broadest, which is only accidental, from the Nerves growing through them with a small Slant.

The *Os Sacrum* hath six *Vertebræ*, but in Adults they appear but like one Piece. It is very smooth within and hollow, but convex without and of a triangular Figure. It hath but very small Processes, and most of those looking upwards; so that the lowest hardly appears. At the Extremity it is joined to the *Os Coccygis*, called so from the Resemblance it bears to a Crow's Bill; it is composed also of three or four little ones, from a longer Base, extending downwards to a Point, which depends inwards for the Conveniency of Sitting. It seems to sustain the straight Gut, and yields its Point backwards, being cartilaginous in Women in Travel; and, if we may credit some Authors, it grows outwards in some Countries, and serves the wild and naked Females for a Covering for the *Pudenda* when chased after. The *Os Sacrum* takes its Name from its being offered as a dainty Bit in sacrifices, as some say, or from the Customs the Romans had of burning the Bodies of the deceased on their funeral Piles, and to throw upon their Faces, which occasioned this to be the last Part burnt. When the

Of the  
Vertebræ  
of the Os  
Sacrum.

R

Ver-

*Vertebræ* of the Back or Loin's are any way relaxed, they are apt to make too great a Curvature in that Part, which, if it happens to be backwards is called Hump-backed; and if laterally, they are crooked, which is very common to young Girls, from the over Officiousness of fanciful Mothers and Nurses. In which Cases, the intervening Cartilage on one Side is always very thin, and, on the opposite Side, very thick; the Reason of which any one may easily conceive.

Of the  
Ribs.

To the *Vertebræ* are joined the Ribs, being twelve on each Side; seven true, and five spurious ones. At their posterior Extremities they are round, with small Heads like two Planes, which answer to the Bodies of two different *Vertebræ*, with which they are articulated, the middle Ridge forcing it self into their intervening Cartilages, thereby securing them from any Manner of Dislocation; and for which Reason likewise, to prevent their being thrust out backwards, they have each another small Tubercle, a little fastened, for their Articulation with the transverse Processes of the *Vertebræ*. Their Substance is spongy for Lightness, and their Figure crooked, like a half Circle for the Defence or Custody of the Parts lying under them. They have all little Furrows on their Inside, which run along

most of their Concavity, for the safe Lodgment of the intercostal Vessels, and the Safety of the Nerves. At the *Vertebrae* they are thicker and rounder, that being their Basis, and make acute Angles with them to enlarge the Cavity of the Breast, and give more Room for the Parts contained, when raised up by their Muscles, and brought to stand at right ones; for without this Position and contrivance, they could have made no Difference, as is necessary they should, and is evident they do, upon Inspiration; wherefore also, at their other Extremity, a Cartilage is made use of to adjoin them to the Breast-bone, that they may give Way to their Motion, the Reason of which was the Cause of a Gentleman's Death, who formerly lived in *Newgate-street*, labouring under the Symptoms of an Asthma, which the Physicians could not imagine the Cause of, till, after he was opened, they found those Cartilages ossified by his Age, which hindered his Inspiration, and was the only Cause of his Asthma.

The seven upper ones, are called the true Ribs, because their Extremities are all conjoined to the Breast-bone, and are the true Custodes or Preservers of Life, defending one of the most principal Parts of the Body, the Heart. And therefore the inferior ones are called spurious,



because they are short, and do not reach the Sternum but are tied to one another, leaving free Space for the Stomach and Bowels to move in, and to all which the Midriff is attacked.

Their Use is to keep the Breast dilated, to support the Respiratory Muscles, and for this Reason the Breast ought not to consist of one Bone. They also serve to defend the Parts contained from external Injuries, from which Use they have their Names.

Of the  
Sternum.

The *Sternum* is that broad, flat, oblong Bone at the anterior Part of the Thorax, which is made up of several little ones, and is very thin and spongy, having a cartilaginous Extremity called *ensiformis* and in some Bodies is biforked. The Use of it is to afford Origins and Insertions to several Muscles; to sustain the *Mediaſti-num*, and, like a Shield, to defend the Heart and Lungs. It consists of many little Bones, for the Advantage of ossifying betimes, which otherwise, as it is so spongy and thin, would have been little better than a Membrane, had it not consisted of several Plates. It is pointed at its Extremity with a Cartilage, to serve as a Leaver to its triangular Muscle, which lines the Insides of it. Another Use it hath is to suspend the Ends of the Ribs

and two

and serve as their moveable Fulcrum to assist in Inspiration.

Under these lye the *Anonymus* or nameless Bones, which makes the Hanches, and guards, like strong Walls, the Parts contained in the Pelvis. It is constituted of three Bones, the Ilium, the Hip-bone, and the Share-bone. The first is situated on each Side of, and strongly united to the *Os Sacrum*. It is something semicircular, but very uneven. The Bone opposite to the Ilium is the Pubis which makes the fore Part of the Basin, as the former does the back Part, and hath two remarkable Holes through each for Lightness, and also for the Conveniency for the Muscles to pass through them, with the posterior crural Nerve, which hath a little Nick in the End on purpose for it. The third is the Ischium one on each Side, in the exterior and inferior Side of which there is, in each, a large Cavity, called, from its Likeness, Acetabulum, which is for a Socket for the Head of the Thigh-bone to move in. This is a very irregularly figured Bone, and situated the lowest of any of the rest, but not one single Asperity belonging to it nor them, which hath not its peculiar Use, which see in *Monro's* full Description of the Bones.

Of the  
Anony-  
mus Bone.

In the upper Part of the Body are the *Clavicles*, of a thick and spongy Substance.

Of the  
Clavicles.

stance as well as the former, resembling in Shape the Letter S, adhering to the Top of the Sternum with a round Head at one Extremity, and at the other, which is flatter, they are fixed to the Process of the Scapulæ where they produce the Tip of the Shoulder called Acromion, and serve, like the cross Beams in Building, to keep the neighbouring Parts from falling in, or pressing too much upon the Thorax; and likewise (as no part of the Body hath one single Use alone) to give Origin to some Muscles, and to guard and defend some large Vessels of the Body.

Of the  
Scapulæ.

The next are the *Scapulæ* or Plate-bones, which lye upon the dorsal Part of the Ribs, like Targets. They have a large flat and thin Basis, and a Ridge or Spine that divides it in the Middle, and three Processes at its smaller End; all serving for the proper Origin of Muscles, the Defence of the back Parts, but chiefly for the secure Articulation of the Shoulder with the Clavicle.

Of the  
Shoulder-  
bones.

Next follow the *Shoulder-bones*, which are long, round and strong Bones, and hollow for Lightness, and to prevent their breaking; for it is well known that the Strength of one Bone, is to that of another, of equal Number of Fibres, as their Diameters; therefore all the Feathers of Fowls are hollow. They are smallest in



the Middle, to be strongest where there is most Occasion for it, and very large at their Extremities, serving as broad Bases for their securer Articulation, having also several Epiphyses, for the convenient Origin and Insertion of the Muscles, and as a Margin to the Periosteum and Growth of the vagrant Fibres of the Bones. They are single, because they have all Manner of Motions, and can describe an entire Circle round the Axis of their round Heads adapted for the Cavities of the under Processes of the Scapulæ.

The *Bones* of the lower *Arms* are two, the Radius and the Ulna; they serve to bend, extend and turn the Arm, pronely or supine, which last Motion could not have been, were they not two of them. The first and superior one is the largest, called Radius, from its resembling the Spoke of a Wheel. It is joined to the Tubercle of the Shoulder-bone at its upper Extremity, and its lower End, which is much larger than the other, to the Bones of the Wrist, which lye in its Sinus's. The Ulna or the exterior and inferior Bone of the Arm, is not at this Extremity, fastened to the Wrist, but is received into a small Sinus, on the Side of the Radius, near its End; but is articulated with the Shoulder-bone at the other Extremity called the Elbow; by

Of the  
Bones of  
the Arms.

Of the  
Bones of  
the Car-  
pus.

which Position and Articulation of these two Bones, the Motions of Supination and Pronation are given to the Arm, which otherwise could not be. At the Extremity of the Radius lye the eight little spongy Bones of the Wrist, which are thus spongy for Lightness, and serve to fill up that Space and give more Motions to the Hand, than it would have, were they but one single Bone or two. They likewise serve as so many Pedestals to the four metacarpal Bones that lye next to them. They differ in Figure, Likeness and Make, and stand in two Rows, four in each; tied together by a strong Ligament.

Of the  
Bones of  
the Meta-  
carpus.

The *Metacarpal Bones* are four, and spongy likewise; serving for Pedestals and Hinges to the Fingers, and to give Bulk and Strength to the Hand; and the better to answer this End, they are round and long, convex outwardly and plain within, touching one another only at their Extremities, to make Room for the Interossei Muscles, and on their round Heads allow their Fingers to move freely.

Of the  
Fingers.

The Bones of the *Fingers* are twelve in each Hand, three of which are in Substance and Shape like the former, only less and less as they approach the Extremities. They are made of three several Bones, to fold the Hand the better in grasp-

grasping. The Thumb hath also three Bones; the first very large and answers to the metacarpal one; the other two being like the former. The Fingers are moved Side-ways only upon the first Joint, the others serving for Flexion only. In the Inside of the Fingers are several sesamoid Bones, which serve as Pullies or Blocks to strengthen the flexor Muscles, under whose Tendons they lie.

The Bones of the lower Limbs are, <sup>Of the</sup> first the *Thigh-bone*, which is single and <sup>Thigh-</sup> <sup>bone.</sup> also much like that of the Shoulder, only larger, and its Acetabulum is bigger and deeper, and hath a round Ligament that comes from its Bottom, near the lower Edge, and is inserted into the round Head of it, at its Axis or central Point, to prevent its Dislocation upwards, which, by our erect Posture, we are the most liable to, whereas in Brutes the Ligament rises from the Centre or Middle of the Socket. It hath likewise several Protuberances for the Use of the Muscles, which, by removing them from the Centre of Motion, so much encreases their Force. They are the longest in the whole Body, not only to make us tall, but to give us the longer Step in Walking, and also to afford Place for the crural Muscles. Its Head and Neck make a large Angle with its Body, which proves of great Service to



to make us stand firm, by placing our Legs at a distance from each other as we stand, as we see more obviously in the strong limbed or well made men, as they call them. It is likewise convex in its anterior Part and hollow behind, for the Conveniency of Sitting. The inferior Extremity of it is very large, and formed into a great Protuberance on each Side called the Knee, between which lies a Cavity, with a remarkable Gland in it, to lubricate that Joint; on the fore Part lies the Rotula.

Of the  
Bones of  
the Leg.

The *Leg* is likewise composed of two *Bones*; the largest and internal called the *Tibia*, and the small external one called the *Fibula*. The first is a long, thick, triangular one, articulated with the *Oss. Femur*, and supports along with it the whole Weight of the Body; for which Reason its upper Extremity is very large and spongy, with two Cavities to receive the two Inosculations of the Thigh-bone, and at the lower End it is articulated with the Ankle-bone, which it receives into its Cavity; the *Fibula* being fixed at both Ends to it, into a Sinus for that Purpose.

Of the  
Rotula.

The *Rotula* is a small flat Bone, situated at the anterior Part of the Joint of the Knee, and serves as a Block to bear the Tendons of the Muscles of the Joint thereby, like a Pulley, to facilitate the Motion.

Motion; and assists us also in walking down steep Places, without which the Knee would often be luxated forwards, when we have Occasion to bend it.

The Bones of the Ankles are seven (for the same Reason those of the Wrist are eight) namely, the Astragalus superior, the Heel-bone posterior, the Navicular-bone in the Middle, the Cube one external, and the three Cuneiform inward. The Astragalus's upper and convex Head is articulated with the two Bones of the Leg, and its under and fore Side likewise convex is received into the Sinus of the Navicular-bone, but on its hind Part lies a Sinus for the Heel-bone, and a small Protuberance for it also to receive. Next to the Navicular-bone lie three or four wedge-like ones, large above and narrow below, to make the Foot a little concave, for the better Security of the Parts contained there, from being pressed too much upon and hurt in Walking. They have Cavities which receive the former into them, and, at their other End, are joined to the three inner Bones of the Metatarsus, and make the thick Part of the Foot. The Cubiform is the seventh, which behind is joined to the Heel-bone, and before to the two outward metatarsal ones. The metatarsal and the other of the Toes, being so like unto those of the Fingers,

Of the Bones of the Tarsus and Metatarsus.

Of the Toes.

we

Of Articulation.

we shall take no farther notice of them, but shall proceed to take notice briefly of the Manner of Articulation or Jointing. That the Bones may be pliable and apt for all Manner of Motions, Nature hath adapted their Extremities with all necessary Conveniencies for that Purpose, and joined them to one another by several Ways and Methods, most suitable to those Parts. In them that have Motion it is called Articulation, which is by modern Authors distinguished into four Sorts: *Diarthrosis*, where the Bones have a large Motion, and are received into Sockets; *Ginglymus*, where they are mutually received by one another, and allow of Motion two Ways; *Synchondrosis* is, when Bones are joined by the Means of an intervening Body, as strong Ligaments or Cartilages; and last of all, *Synarthrosis*, which is subdivided into *Sutura* and *Gomphosis*; of the first Sort are the Articulations of the Bones of the Head and Face; of the second the Teeth. Some Authors heap up many more, but these I think are sufficient to account for all the Junctures of the Bones, without burthening the Memory of those, to whom such Things are not very familiar; for under the first is comprehended the Articulation of the Thigh-bone with the *Ischion*, and the Shoulder with the *Scapula*. Under the second

Head



## Of the CARTILAGES and LIGAMENTS. 253

Head is included the Articulation of all the Flexors ; as the *Vertebræ*, the Bones of the Arms and Knees, and the first and second *Vertebræ* of the Neck ; in which Cases, one Bone, with one or two Protuberances, enters the Cavity of another Bone, and sometimes is received by it. Under the third Sort, come all the Conjunctions of Bones for slow or no Motion, as between the Heel-bone and the Astragalus, the *Os Pubis* and the *Ischium*, and the like : And lastly, under Synarthrosis, the Sutures of the Head, and the Position of the Teeth are understood ; for there is no such Conjunction as Harmonia, as by some reckoned, it being only the finest Indentation of those Sutures, which makes them appear, as one simple smooth Line.

## CHAP. XX.

### Of the CARTILAGES and LIGAMENTS.

**A** Cartilage or Gristle is next to a Bone in hardness, but more pliable and most elastick of any Part in the whole Body. Before it changed into this Nature, it was, at the first, a Membrane ; for plain it is, that there can be no Bones in a *Fœtus* in the first Month ; they there certainly are

The Nature of Cartilages.

are only the membranous Stamina of them.

The Extremities of the Bones are generally lined or tipped with these; and more especially in those Parts where there is a Necessity for a resisting Power; and all the small Bones, that have frequent Motion, have their whole Surface *Cartilaginous*. And for this Reason, the Apophyses and Cavities of the Joints, are all covered with a Cartilage, that they may, of their own accord, result or fly back, when they are turned about. And this is the most convenient Substance that could possibly be invented for this Use, by reason the Friction of them is the least that can be; for they waste not the Liquor so fast as another porous Substance would do, and they slide very smooth and easy upon one another; wherefore they have no Cells to contain Marrow in, nor are covered over with Membranes, which would make them sensible; but their Nourishment easily penetrates and soaks into their softer Substance and broader Pores.

Their  
Differences.

They differ in Bigness, Shape, Situation, Connection, Hardness and Use; some constituting the Parts, as in the Ear, Nose and Trachea; and others spread over some principal Part, as in the Ribs and Sternum.

Their

## Of the CARTILAGES and LIGAMENTS. 255

Their *Uses* are several and various: To render the Motion of the Joints easy; to join several Bones together; to withstand the hard Resistance or violent Pushes of some solid Bodies; to make some Parts of the Body as the Wings of the Nose, the external Ear and Wind-pipe and the Epiglottis; and last of all to enlarge the Cavities of the bigger Joints for their firmer Articulation.

But above all the *Cartilage*, belonging to the Knee, called from its Figure *Lunata*, is most remarkable; it is very soft and supple, and runs in betwixt the Extremities of the two Bones, becoming very thin at its Edge. Its Use is to secure the two Protuberances of the Thigh-bone, from slipping out of the Sinus's of the Tibia, and to facilitate small lateral Motions in that Juncture.

Another Substance, and useful Part, a Degree softer than these, are the *Ligaments*, which have no more feeling than the former, and are proper to all the Joints, and are of two Sorts; the burfal and the round ones. They are dry, firm, loose, flexible Bodies, appointed for the Fastening together of the Joints. Their Figure is broader or narrower, round, flat, shorter or longer according to the Variety of the Parts they are fixed to, arising from a Bone,



## 256 *Of the* CARTILAGES *and* LIGAMENTS.

Bone, Gristle, or Membrane, and inserted into the same.

Of the  
Use of the  
Bursal and  
their  
Glands.

The *bursal* Ligaments enclose the whole Joint, as in a Bag or Purse, on the Inside of which are many little *Glands*, as *Havers* observes, to keep them always moist and smooth. They serve to keep the Heads of the Bones secure and free as in a Case, and to separate Liquor to lubricate them with, as also to keep them in their right Places.

Of the  
Use of the  
round Li-  
gaments.

The round *Ligaments*, are white, round, solid Bodies, which fasten those Joints together, that have a rotary or flexory Motion, as in the Thigh-bone, where it is fixed to the Axis of the round Head that plays in the Socket. But in the Humerus or Shoulder-bone, there is none, because its Motion describes a Circle, and so would be but troublesome, when twisted, which it would be often liable to. In those Joints that have the Motion of Flexion, there is one on each Side, like Hinges, to keep them right in their Places, and are inserted in a very particular Part of the Bone; so that in the whole Motion of the Joint, its other End remains at an equal Distance from it, that is, the Centre of Motion in that Joint, thereby gives no Impediment to its Motion. These all serve to fasten the Bones, that they may not be easily dislocated upon Exercise.

To

To these we may add a third Sort of *Ligaments*, which keep the Parts fixed in their Stations, without any remarkable Motion; as the Suspensory one of the Liver; the umbilical Ligament and Ura-  
chus; the broad and round Ligaments of the Womb; the annular Ligaments of the Wrists and Ankles; those of the Head, Jaws and Tongue, with those of the whole Trunk, Ribs, Sternum, Ilium, Sacrum and *Os Pubis*; together with those of the Scapulæ, Arms, Hands, Legs and Feet; all which are to be found described at large, in every Book of Anatomy, and differ from the former only, in not being quite so hard, or otherwise are alike, in all other substantial Circumstances, and are but a coarser Sort of Membranes.

## CHAP. XXI.

*Of the* MUSCLES.

THE next Covering that is spread over the Bones, next unto the Periosteum, is, the muscular Substance of the Body; under which Denomination is understood, all that Portion of the Animal, which is properly called Flesh; which is not one continued Substance over the whole Body, but consists of several distinct  
S and

and separate Parcels that lie by, and upon one another, in such convenient Order and Posture, as best conduces to the Comeliness of the Body, and right Performance of each one's proper Office.

The Substance of the Muscles.

The distinct Substance of each Muscle, is made up of a Bundle of them, being parallel fleshy Fibres inclosed in one common Membrane, which each Muscle hath proper to its self, to serve for Partitions to separate them from one another, and to confine the Fibres of their respective Muscles from irregular Divarications. All the Fibres that constitute a single Muscle, are longitudinal and parallel to one another, lying close together, and are intersected by other transverse Fibres, that tie them to each other, at extremely little Distances; thereby forming little Spaces or Cells, between each Intersection. This is the rough and common Appearance of the Muscles, which, if more narrowly looked into, will appear the same, but much nicer in their Structure; where these fleshy Fibres may be seen, composed of other small ones inclosed likewise by a common Membrane, each lesser one consisting of very small Vesicles or Bladders, for the Inflation of the said Muscle, for which Purpose each hath a fine imperceptible Artery, Vein and Nerve, which are emptied into them for that Purpose.

The



The Muscles, by Anatomists, are divided into the Head, the Belly and the Tail; the first is where they arise, which Origin is generally a little tendinous, but mostly fleshy; the second is the fleshy Part of it or Middle; and the Tail is the white and tendinous Part.

The Division of a Muscle.

The two Ends of each Muscle are fastened to two Points, that lie under them. The one is generally moveable, and in this Place it is said to be inserted; the other End is always fixed, and from that it is said to take its Origin, whence, when a Muscle acts, so that it grows shorter in Length, it draws the moveable Part towards it, according to the Direction of its Fibres, and so produces the Motion of the Parts. Wherefore we may reckon, all the Muscles, as so many moving Powers, fixed to so many Bones as so many Levers, and the Parts themselves to be raised, as so many Weights to be moved, and Resistances to be overcome.

Of their Origin and Insertion.

But sometimes a Muscle runs over two Joints, and thereby moves both; each with half that Motion it would one singly with, if all its Force did not belong to two Joints, and so may have either End called the Head of it.

Moreover, though all the Muscles in general, consist of fleshy Fibres, intersected with transverse ones; yet there is some

Of their Differences.

Difference amongst them, with respect to the particular Course or Direction of these Fibres; the most remarkable Being of two Sorts; the Rectilineal and the Pinniformed. The Muscles of the first Sort are most common, and most powerful, having the Direction of their Fibres parallel and longitudinal, in the same Direction with the Axis of the Muscle, and serve for Strength. The second Sort of Muscles, or rather second Order of Fibres in the Muscles, are called, from the Resemblance their Fibres bear to the Stria of Feathers, Pinniformed; having all their Fibres running in an oblique Direction, from their Tendon, along their Axis, to their common Membrane on their Surface. These are fewer in Number than the former, Nature never using these, when the other Sort are fit, because their Fibres being slanting, occasion them to lose much of their Power, which they would have, were they streight as the other, which they must not be, for Reasons shewn hereafter.

The Rectilineal Lines act strongest.

Now it is a known Law in Mechanicks, that an oblique Force is to a perpendicular one, as the Sign of the Angle of Incidence is to the Radius, that is, the more obliquely any Power acts upon a Body, the less its Force is; wherefore the Pinniform Muscles cannot act with the same Degree of Strength

Strength, as Rectilineal of the same Bigness can; by reason of the Obliquity of its Fibres to the Plain of its Infertion, and which those of the others are perpendicular to.

But then, if these Muscles cannot have that Advantage of Strength with the former; they have another Advantage of their own, which the others have not, that is, the greater Celerity of their Motion; for as in all Engines, the greater the Force is, which is required to raise a Weight, the slower is the Motion, so *vice versâ*, the less the Force, the quicker the Motion. Just so it is here; for by reason of the Obliquity of the Fibres of those Pinniform Muscles, their Power becomes much less than that of the others, but then they exceed them as far in the Velocity of their Motions, which propensates for their loss of Strength.

The Pinniform Muscles quickest.

Nor does the Motion of the Pinniform Muscle act uniformly like the other, by reason in their Contraction, they grow more and more oblique, and consequently their Velocity increases as their Strength decreases; and, as I said before, Nature never uses these, when the other can do as well. And the Reason, why the rectilineal Muscles cannot do in all Places, is, when the Muscle required for such a Place is to be so big, that their Fibres in



the Action would press upon one another, and thereby hinder each other's Contraction, and not have a Lever to act with, suitable to their Quantity of Contraction; as for Example, the Fingers and Toes.

Of the  
Difference  
in Muscles.

These are the most remarkable Differences relating to the Muscles, though they have several lesser ones, among themselves, as Magnitude, Figure, Length, Breadth, Situation and Use; for all which we refer to other Authors.

The Na-  
ture and  
Use of  
Tendons.

*Tendons* are fine Strings or Cords, that proceed from the Body of the Muscle at its Extremity, being a Continuation of its Fibres, only of a different Texture, being more close and solid; which gives them their fine white Colour. They belong chiefly to such Muscles as move the Bones, and are kept close united to the Parts they pass over, to prevent their being at any Time misplaced from their streight Course, and are inserted near the Centre of Motion in the Joints, which, upon swelling of the fleshy Part of the Muscle, are drawn upwards, or towards it, together with the Lever or Bone, which they are fixed to.

In the Limbs, some of the Muscles pass over two Joints, both which they are apt to move at once, with Motions proportionable to the Difference of their Levers, and if either chance to be fixed fast

by its Antagonist Muscle, then the whole Action of that Muscle, will be wholly exerted on that other Joint that is at Liberty, and be moved with a Velocity equal to the Velocity of both these Joints, when both are moved at once. And the Reason of this Mechanism is, to supply, instead of a greater Number of Muscles, what must have been, without this great Contrivance.

Now for a Muscle to act regular and exact, it must be inserted at a certain Distance over the Centre of Motion in that Joint, which it moves proportionably to its Quantity of Contraction, and of the Motion of that Joint, which holds true in all Muscles; and it is certain, without this Care, the Muscles could not answer their End so well as they do; for was a Muscle inserted too near the Joint it moves, then this Inconveniency would necessarily follow, that all the Motion of that Joint would be performed, before the Muscle would be contracted as much as should be; and, on the contrary, was a Muscle to be inserted a little farther from the Joint, then the reverse Inconveniency would happen, that the Muscle would have done contracting, before the Joint was moved as much as was necessary; whence it follows, that all Things being as now they are, there can be no Place

The Muscles are all inserted in the best Point belonging to the Bone.

found, where the Muscles can be better inserted, than where they are. For if, suppose, a Muscle can contract three Inches, and should be inserted an Inch farther from the Joint than where it is, the Joint would want to be drawn four Inches; but the Muscle, in this Case, not being able to draw above three, the Joint must necessarily want an Inch of its Motion; and on the contrary, if a Muscle was inserted, one Inch nigher than what it is, and be able likewise to contract the three Inches, the Joint wanting but two Inches for its Motion, one Inch must be lost, for the Muscle can draw the Joint as far as it can possibly come by Inches of Contraction alone; therefore the third Inch will be superfluous.

The different Strengths and Quantities of Motion of the Muscles, and whence.

Again, as to the Strength of the Muscles, those are always the strongest that are the thickest; for this is certain, that the Quantity of Motion in a Muscle is, as the Length of its Fibres, and its Strength as the Number of them. Now, suppose, for Example, that one single Fibre can raise up the Weight two; then thirty such Fibres shall raise up thirty times the Weight two; so that the Sum of the whole Strength of that Muscle shall be the compound of the Sums of every single Fibre thereof; and consequently then, the Weight that a Muscle can raise will be always



always as the Number of its Fibres; and therefore the absolute Strength of one Muscle is to that of another, as their Bulks or Thickness.

Thus, as the Strength of a Muscle is, as the Number of its constituent Fibres, so the Quickness and Quantity of its Motion is, as the Length of those Fibres; for the Mechanism of the muscular Fibres is like so many Strings of Bladders joined to one another, like so many fine Rows of Beads, which, upon Inflation, by an elastick Fluid, conveyed into them, causes their Sides to distend, and their moveable Extremity do draw up or contract, and thereby to become shorter, and so the Member is raised, according to their Direction. Now the longer these Fibres are, the more of these little Bladders there will be, to be inflated; and as every one contributes something, the Sum Total of their Contraction will be as their Number: As for Instance, suppose, that one Fibre consisting of two Bladders, can draw a Joint one Inch, and with the Velocity three; then double the Number of Bladders, in a Fibre, will move it with double the Velocity, and double the Quantity of Motion: Therefore, the Velocity and Quantity of Motion in a Muscle is as the Length of its Fibres, which is as  
the

the Number of Bladders in a straight Line.

Of the  
Use of the  
Tendons.

The *Tendons* are no ways here to be considered, as of any Force or Strength of a Muscle acting, because they admit of no Inflation; nor indeed does Nature ever use them, but in such Cases, where there is not room for the Insertion of so many fleshy Fibres as the Muscle consists of; or where the Muscle must draw from one certain Point, thereby throwing all the separate Actions of all their muscular Fibres into one Point, making the *Tendon* as it were their ~~original~~ Line to compound their separate Forces in.

diago -

Muscular  
Motion  
how performed.

Thus far, having considered a few general Remarkables concerning the Muscles of the Body, we come next to enquire, how they do act. We have already seen how far they are suited for their several Functions; let us now examine, the Manner how they perform them. In the first Place then, we are certain that one general Way is used by them all. And secondly, we are no less sure, that a Nerve and Artery are absolutely necessary for their Action; and therefore, thirdly, we conclude it as certain, that this is performed by a Fluid that comes from each of those two Vessels, viz. Blood and Animal Juice for, as for other Fluids, there are none there, and to proceed from the Solids and

one, is impossible to be done. And thus far we are certain ; but in the next Place, as to the Modus of the Muscles swelling, and how that is performed by these said Fluids, makes all the Difficulty, which, if it can be resolved by a mechanical Demonstration, will prove a Discovery so great ; as to signalize this present Age, whilst Time and Nature do endure ; for most Authors, who have hitherto offered no account for it, have betrayed much Weakness in their Hypotheses, and at last been obliged to leave it in Obscurity, as they first found it. But to leave every Man to his own Opinion, we shall here only examine the most modern Theory of it, as being the most reasonable of any, and most prevalent at the present Time, and though it is mechanically accounted for, yet it does not escape strong Objections by Men of no less Learning, than the first Defenders of it.

Vid. the Introduction to Cowper on the Muscles.

To understand then how muscular Motion is performed, we must consider two Things. First, The adapted Structure of the Fibres of the Muscles for that Use ; and secondly, the Property of the two Fluids that act in them. As to the first, it hath been observed by ocular Inspection, which is the best Information, that their Texture or Mechanism is like unto so many fine Vesicles or Bladders, tied to one



one another's Extremities, and that each single Fibre is a distinct Chain of the said hollow Pores, divided from each other by the transverse Fibres, which hinders their too free Communication with one another, which would have been very inconvenient, by causing the Inflation of the Muscle to be irregular, and not uniform, but more distended in one Part than another.

Now, when all these little Bladders are filled and distended with an elastick Fluid within them, their Sides will, by this Inflation, be made, as all blown Bladders do, to recede from their Centre, and form a spherical Figure, whereby their two Ends are made to approach nearer to one another, and so the Muscle, suffering this Effect in every Fibre, will swell in Breadth, and contract in Length, and so raise its Lever, as we may feel in the masseter Muscle and others.

What puts  
them in  
Action.

This being the mechanical Aptitude in the Structure of the Muscles themselves towards their Motion; secondly, let us next consider, what it is that puts them on their Action. Indeed, the Antients thought and but a Thought, that it was the animal Spirits alone, that filled the Muscles and caused them to swell; and how should they know better, when the Method they took was not conclusive. But that it proceeds not from the nervous Juice alone

but by the Assistance of another Fluid besides that, is plain from the Loss of Contraction a Muscle suffers, upon its Artery being cut or tied, as well as when its Nerve is ; and therefore we must believe, that the Blood is as necessary for this Action as the animal Spirits. This Knowledge being gained, we are next to examine, how these two Fluids can be able to produce this wonderful Effect of distending these Vesicles of the muscular Fibres ; which in short cannot be from their Quantity, but their Quality only ; for could the first do, there would be no need for two Fluids, there being always Spirits enough in the Nerves to have filled them, without the Addition of the animal Fluid, had this been performed by Quantity alone ; or supposing there is not a sufficient Quantity of the nervous Fluid to distend these Bladders with, it is plain the Blood can add no Assistance to it, by augmenting the Quantity, for as much as its Motion being uniform, it abounds not more in the Muscles when in Action, than when in a relaxed State ; therefore it must arise from a joint Mixture of both, which by Rarification expands the muscular Cells that contain them.

And the Manner of this Rarification from the two said Fluids is somewhat after this Manner ; upon the Determination of

The Manner  
of Con-  
traction.

of the Will, the nervous Juice is protruded more plentifully into this or that Muscle; where distilling into the small Vesicles of the muscular Fibres, it is mixed with the globular Parts of the Blood, as it circulates through them, and causes it to expand, and so take up more Room or Space than before, thereby causing a Contraction of the Muscle.

Of the  
State of  
the Blood.

But to be the better understood in this Affair, I must here show, how the animal Spirits or nervous Juice can cause the Blood to take up more Space, by its mixing with it in the cellular Pores of the muscular Fibres, than it did before, and to distend them with a Force sufficient to raise a great Weight, and overcome a prodigious Resistance. To do which, we must consider these two Fluids separately and see what Properties belong to them in particular, that can produce such an Effect, when applyed to each other. First as to the Blood we know, that its Parts are either serous, chylous, or globular. The two first have nothing to do in this Affair, but only the red *Globuli*, the Texture of which we know consists of many concave Spheres filled with Air made of the fine viscid Parts of the Blood by the Action of the Lungs in Expiration which forces into each, a small Quantity of compressed Air, which is retained



that State, by the strong Nifus or Attraction of the constituent Particles of the Shell or Globe that contains it. And that this is so, is evidently to be seen by a Microscope, that where the Diameter of a Canal is less than the Diameter of a Globule of Blood, the Globule will be pressed from its spherical into a spheroidal Form, till it comes at a wider Part of the Canal, and then it reassumes its former Figure. Besides, the great Quantity of Air the Blood yields in the Air-Pump, to me puts it past all doubt, that there is much Air in the Blood, and that these Globules are nothing else but small Cases of it. This being the State and Condition of the Globules of the Blood, we must add that of the nervous Juice.

Now the Minuteness of the Glands of the Brain, and the exceeding Smallness of the Fibres of the Nerves, plainly shew the animal Spirits to be a Fluid, consisting of the very smallest Particles of any in the whole Body; and it is plain, that they have no great chymical Quality nor Texture, but what arises from their fine balsamick Nature; therefore, all the Action they can perform, must be, or proceed from their Force and Degree of Attraction, proceeding from the exceeding minuteness of their Parts. For first, it is a settled Position amongst Philosophers, that

Of the  
State of  
the nervous  
Juice.

At-

Vid. *Wor-*  
*ster's* com-  
 pendious  
 Account  
 of the  
 Principles  
 of Philos.  
 P. 18.

Vid. *Bel-*  
*linus's* me-  
 chanical  
 Account  
 of Levers  
 P. 17.

Attraction is stronger between small Particles, than large, if the Particles are equally dense, and the Surface of Contact equal; for the Effect of the same Force, hath a greater Proportion to the Weight, and inertia of a small Quantity. All which holds true in the nervous Juice, and therefore acts upon the Blood in that manner, whenever it meets with it. But although this nervous Liquor constantly moves through the Nerves, yet it does it very slowly, and does not fall into the Cells, whereinto the Nerves open continually, but alternately; nor is it necessary, that the Times between every Efflux should be equal in every Part; for they may be greater or less, yet so frequent as to appear continually to distill and produce Effects continual in Operation. But where the Muscles have equivalent Powers, it is imperceptible, in others not so. This is the true Case of the constant tonic Contraction or Action of all the Muscles. But when, upon the Determination of the Will, more Liquor is protruded into these Cells, that acts more powerfully on the Blood than before, and by surrounding the Globules, attracts the Particles of which they are composed, more strongly than they do one another, and consequently therefore, their Nisus to one another, seizing the condensed Globuli of Air, will expand

expand it self with a very considerable Force, whereby each Bladder will be distended, and consequently every Fibre shortened.

I say, the Condition of the two Fluids being thus, as we laid down, it will follow, that if a Drop of nervous Fluid be thrust into the Vesicles of the muscular Fibres, it will surround the Globules that pass each Pore, and strongly attract its Parts, thereby weakening the mutual Attraction of one another. Then, and only then, is the Time when the Blood rarifies in the Muscles, and puffs up the Vesicles; and all this is caused by taking off the Nisus of the globular Particles to one another, to let the compressed Air have room to expand in, and so take up greater Space than before; and just so long, as this Attraction of the globular Particles, that constitute that Shell or Case, that encloses this Air does last, the Muscle continues contracted. But when the Particles of these two Fluids come to be united, and act uniformly, they will, by their conjunct Force of Attraction, soon reduce the globular Shell of Blood into its former Dimension, and consequently the Air into its pristine State of Condensation. and then the Action of the Muscle ceases, unless a fresh Supply of animal Spirits be continued to it; and even then, when a

T Muscle

How the Blood is rarified and expanded to cause Contraction.

Why the Contraction of a Muscle ceases, or continued.



Muscle hath been contracted a long Time, the Quantity of Spirits which it hath spent by that continued Action, being more than can be separated by those Glands of the Brain that answer it, quick enough to keep it longer inflated, it must necessarily be tired, and fall, its Nerves being empty, and not supplying any more Fluid; whereas the tonick Motion of the Muscles, being performed by the Spirits protruded only by the Quantity last separated in the Glands, will constantly continue whilst Secretion goes on, without any Weariness.

Not from  
Ebullition  
or Effervescency  
of the  
Blood.

From thus much said, we see, that the Inflation of the Muscles proceeds not from any *Ebullition* or *Effervescency* of the Blood, and their Distension to cease, by a Precipitation of Flying off of the aerial Globules through the Pores of the Muscles as some, being strained in their Notions have thought; for so they would remain sometimes, for a long Time against our Will, even granting that the Air could pass off through their Pores, which is not at all likely: But instead of that, the Globules, upon the Influence of the animal Spirits, do not burst by the Expansion of their contained Air, nor pricked by angular Particles of that Juice, as some are pleased to fancy, but do recover their former State and Dimensions, as we have

said above, and are carried again, along with the common Course of Circulation.

Against this Theory of muscular Motion, there are several Objections, all which, I shall not, at the present, take upon me to answer, but to these following, shall say thus much ; First, as to those who deny all Air from being in the Blood, and that there are no such hollow Globules, as we have been speaking of, I refer them to the Air Pumps in the one Case, and to the Microscope in the other to convince them ; and as to the Manner, how these Globules are first formed, I shall shew in their proper Chapter, where I come to speak of that Fluid.

Objections answered.

Now in the Air Pump, many Bubbles of Air are seen to arise from the Blood, which could not be, were there no such Particles in it before ; neither can it be said, that they got into its Pores, after its separation from the rest of the circulating Mass : For we find, that, as the great Dr. Mead hath observed, the Sun and Moon effect us, by taking off part of the Pressure of the Circumambient Atmosphere, and thereby let the internal Air in our Vessels expand the more, and cause several Symptoms, according to the Constitution of the Fluids, as we find in People weatherwise, and those that are subject to nervous Disorders, who chiefly,

at that Time, and from that Cause are always affected. And that the crassament Parts of the Blood are so many Globules containing Air, is evident, from the several Alterations they undergo in their Figure, according to their Weights, or narrowness of the Vessels they pass through, as Spheroidal in a very streight one, Spherical in a larger, all which besides other Arguments sufficiently prove Air to be in the Blood.

Attracti-  
on neces-  
sary.

As this is the State of the Blood, I assure, they can with much less Reason object against the powerful Attraction of the Particles of the animal Spirits on the former, which is so necessary a Point belonging to this Phænomenon; and without allowing some such Thing, they will never be able to account for it. For as the animal Spirits are a Fluid, consisting of the smallest Particles of any in the whole Body, it follows that their attractive Force, is, by so much the Stronger than any of the others, as Sir *Isaac Newton* hath calculated concerning the Rays of Light; therefore it is no Wonder, if the Particles of the animal Spirits, attract the Particles of the globular Shell, stronger than they attract one another, and thereby take off part of their Nifus, whereby they endeavour to come together.

Again, some go so far as to deny any such Structure to the Muscles, as we have described



described, and tell us, it cannot be, because the Muscles, when contracted, do not encrease in Bulk; whereas it should of Necessity follow, that they should become much larger upon Inflation, if our Hypothesis were true. In Answer to which I can say, they really do encrease in bigness at such Times, or else, how can they heave up a small Weight that is laid upon a large one of them; and upon gnashing of the Teeth, the masseter Muscle, may be sensibly discovered to grow bigger, when contracted; and the Reason why their Increase is not more apparent to us is because there are many empty Spaces, betwixt the Fibres of the Vesicles that frame the Muscles, which upon their Inflation give Way to them, and are filled up by them: Wherefore it is no Wonder they are not more sensibly perceived to increase in Bulk, when in Action, considering the Vacuities of the Muscles themselves, of the Fat, and of the Skin, are all sufficient to make Way for their Increase, without making any considerable Protuberance on the outward Surface of the Body. Besides, it is highly necessary, that the Fibres of the Muscles themselves, should have many Interstices or void Spaces between them, otherwise upon their contracting, instead of shortening their lengths, and, by that Means, raising a

T 3                      Weight

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T 3

Weight



Why the  
Rectilineal  
Muscles  
are not  
thick if  
short.

Weight or moving a Part, they would certainly press hard upon one another, and thereby disappoint themselves, and perform no Action at all. For this Reason it is that the Rectilineal Muscles, are never very thick, if they are short; because, the external Fibres would compress the internal when in Action, and so make themselves almost useless; and in Cases, where this Inconveniency can no Ways be prevented, Nature makes the internal Fibres of a Muscle to be longer than those that lie nearer the external Surface, on Purpose for them to gain by their greater Length, that Degree of Quantity of Contraction, which in another Part of their Fibres they were obliged to lose, by the lateral Pressure of those superficial Fibres that lay upon them; and hereby are made to be equal in Action, the one unto the other, though of different Lengths.

Wherefore, that Experiment our Objectors use, of putting ones Arm or Leg into a Cylindrical Vessel, and then to fill it with any Fluid, as Water, to the very Brim; where upon the Contraction of all the Muscles of that Member, the Water does not alter its Height, nor flow over the Edges of the Vessels; this, I say, is of no Force or Efficacy against us, because, considering the sponginess of the Muscles and Skin, there is Room enough within

it self to admit of their necessary Inflation, without that vast Extension of the Muscle which they argue for; and which indeed could not be, unless the whole Muscle was but one entire Vesicle or Bladder; for as the Case is, the exceeding Smallness of their Vesicles, is enough to prevent any such manifest Protuberance on the Skin, or visible Encrease, which they suppose would follow from their Extension.

And this is the greatest Argument some have used to prove it, for, say they, suppose one large Bladder can raise a Weight one Foot, a hundred little Bladders, whose Diameters are each one hundred Part of the large one, or the hundredth Part of an Inch, can raise it to the same Height, but with ten thousand Times less Force of Inflation, and the Swelling or Room they take up, will be in the same Proportion, and so by diminishing the Bigness of Vesicles, and increasing their Number, the Force required to distend them, and the Distension it self, may be demonstrated in any given Proportion, till at the last it becomes insensible. But even this is not without its Opposers. Those that would hear more of it, may consult the Introduction to *Cowper* on the Muscles.

Vid. *Cowper's* Introduction to *Cowper*.

Thus much being said on the *Muscles* in general, we shall next touch on the

Of the particular Structure of the par-Muscles.

particular *Structure* of some of the more remarkable ones; where we may behold surprizing Art and Wisdom in the nice Mechanism and wonderful Design of them; sufficient to convince the most obdurate Atheist and Libertine, in the Belief of a supreme and vigilant Power, and which are reckoned by some to be four hundred and fifty single ones in the whole Body.

Of the  
Muscles of  
the Abdo-  
men.

And first of the five Pair belonging to the *Abdomen*. The first of which that offer themselves to view are, the Oblique descending, arising from the Ribs, and are inserted fleshy into more than one half of the outward Limb of the *Os Ilium*. It serves to pull the Ribs down in Expiration, and, as *Cowper* observes, to turn the Trunk of the Body on the *Vertebrae* of the Loins to one Side.

Next to these are the Oblique ascending, which have just the reverse Course with the former, and much the same Use. The third Pair are the Pyramidal, which arise fleshy from the Middle of the *Os Pubis*, and are inserted into the *Linea Alba*. Their Use is to pull the lower Belly downwards, to compress the Bladder in making Water, according to *Fallopious*. Sometimes when the following are very large and strong, they are wanting; sometimes one only, and sometimes both, when the straight Muscles act in their stead. The Recti  
arise



arise from the anterior Part of the *Os Pubis*, and are inserted into the cartilaginous Extremities of the Ribs, near the Breast-bone. They serve to compress the fore Part of the lower Belly, to pull down the Breast to the Knees, and *Econtra*, to draw the *Os Pubis* towards the Breast, as in rising from a decumbent Posture.

Under all these lie the fifth and last Pair, <sup>Their</sup> called the Transversal, arising, on each <sup>Use.</sup> Side, from the transverse Processes of the Loins, and meet in the *Linea Alba*, which they form with their Tendons. They serve to squeeze the Sides of the Belly, and assist in Expiration. They all serve, when acting together, by making an equal Pressure to expell the Fæces in the Intestines, to assist Women in Labour, and to expectorate Matter from the Lungs: For which Reason their Levers are not moveable as those of other Parts, yet answer their End, as well by the Swelling of their Bellies as by single Contraction, whereby they the better serve to protrude unnecessary Contents, both from the Breast and Abdomen; and if the Breath is retained in the one, to make a counter Pressure with the Force of the Muscles, then their Action will be downwards; but on the contrary, if the Air is not stoped in the Lungs, but hath free Vent, then the Direction of their Fibres will be upwards,

wards, as in Coughing, and common Expiration.

The Recte, why divided.

Another observable belonging to these Muscles, is the many Divisions made on the straight ones, by intersecting Tendons, which makes them appear like so many distinct Muscles; the Design of which is, that their Swelling or Inflation might not be irregular, or too much in one Place, as they are very long, and their Pressure is differently required. Wherefore, had there not been this Provision made, they would have swelled most in the Middle, where there is the least Occasion for it; but by means of this Direction or these Divisions, their Action is regulated so, as to be most, where most is wanted; therefore they are largest at their lower End, because the Pressure in the Intestins is greatest there upon them.

Of the Intercostal Muscles.

Next to these are the *Intercostal Muscles*, being two and twenty Pair in all; eleven intercostal Internal, and as many External. They arise from the lower Edge of each superior Rib, and are inserted into the Upper of each inferior one; the External running obliquely from the back Part forwards; and the Internal, from the fore Part backwards, their Fibres intersecting one another, like the Letter X. Their Use is, to dilate the Cavity of the Breast in Inspiration, by pulling up the Ribs

and making them stand on the *Vertebræ* at right Angles. It was formerly thought, that the External dilated, and the Internal contracted the Cavity of the Thorax, and some think the contrary Muscles do it; but neither think right, for they both serve to dilate with, as the Mechanism <sup>Their</sup> of their intersecting Fibres demonstrates; <sup>Use.</sup> for by their crossing each other obliquely, they compound a third Motion, whose Direction is in their diagonal Line, and so produces the same Motion as if their Fibres were streight, and went direct from one Rib to the other, and to much better Advantage, because of the very little Space there is between the Ribs for them to have acted in, which would have hindred them of being of that Length, which the Quantity of their Contraction requires; therefore no better Method could have been contrived for the due Length of their Fibres, and perpendicular Direction of their Forces from one Rib to the other, to draw the inferior ones up with, than this of their crossing one another. Besides, as a further Proof that they both serve for the same Action, we may observe, that the Motion of a Part, is always from that Place or Joint that is firm, to that which is less fixed. So here the lower Rib is successively articulated looser than that which is immediately about it; and therefore



fore it must needs be, that both the Internal and External concur in pulling the Ribs upwards.

Of the  
Muscles  
that raise  
the Ribs.

But besides these, there are several other *Muscles* of the Thorax which assist towards elevating of the *Ribs*, and dilating of the Thorax; as the *Scalenus*, which is a long irregular figured Muscle, arising from several Places, as the fourth, fifth and sixth transverse Processes of the Neck, and are inserted separately into the first and second Rib. The next is the *Subclavian*, arising from the Clavicle, and is inserted also into the first Rib, because that hath no intercostal Muscles, it being the Superior of them, and some think, the *Serratus Major Anticus*, and the superior *Posticus* do so; the first arises from the Basis of the Scapula internally, and is inserted into the eighth superior Ribs, by an equal Number of fleshy Digituli, like so many Teeth of a Saw, and serves likewise along with the former to dilate the Thorax, though it moves the Scapula also, and is generally reckoned in the Number belonging to that Bone. The other arises from the lower Part of the Ligament of the Neck, from the acute Process of the last *Vertebra* of the Neck, and two or three of the Back, and is inserted into the second, third and fourth Ribs, by as many particular fleshy Slips or Pointings, serving to elevate those Ribs upon

upon Inspiration, which the Scalenian and Subclavian Muscles did not reach to.

These are the *Muscles* that serve for the Elevation of the Ribs; but their being assisted by their own Gravity, they require not so many to pull them down again upon Expiration; therefore they have but ten proper Pair, which were first found out by the industrious Mr. *Cowper*. They arise from the upper Part of the Rib, wigh its Juncture, and then spreading into a broad and thin Belly, they pass upwards under the Pleura, obliquely over one Rib, and then terminate in that next above it: This they do, that their Strength may be the greater, which always is as the Length of their Fibres. They all serve to depress the Ribs upon Expiration. But that upon Contraction of these Muscles, they might not occasion the Breast-bone to yield, there is a Muscle situated on it, called from its Figure, *Triangularis*, which arises from the ensiform Cartilage, and the lower Part of the Breast-bone, and is inserted into the cartilaginous Endings of the fifth, fourth and third Ribs, near their Conjunction with the Bones. Its Use is to assist the former, in contracting the Cavity of the Thorax, by pulling down or compressing the cartilaginous Extremities of those Ribs.

Of the Muscles that pull down the Ribs.

But

Of the  
Midriff.

But besides these two Sorts of Muscles of the Thorax, there is one common, that assists in both the foresaid Actions, namely, the *Diaphragma* or *Midriff*, which is a compound Body made up of two Muscles; the first and superior one arising from the Sternum and the Ends of the last Ribs; its Fibres running from its semicircular Origin towards its Centre, makes the tendinous Part of it. The second and inferior Muscle arises behind from the Loins, by two long tendinous Productions, which, joining with the former, makes that Partition between the Cavity of the Thorax and Abdomen, called the Midriff; it is perforated in the middle and tendinous Part, by the ascending *Vena Cava*, and the rather here than any Part else, that the Muscle, when contracted, might not stop the Blood's Ascent; and in the fleshy Part of the superior Muscle, by the Gullet (which rather assists than disturbs the same in Swallowing) and the eighth Pair of Nerves; between its two tendinous Productions descends the aorta and the thoracick Duct ascends; the intercostal Nerves pass down, and the *Vena Sine Pari* mounts upon the right Side; which is the most convenient Passage for them, to shun the repeated Impulses of this Muscle in Motion. Its natural Situation is somewhat like an inclined Plain, high before

and



and low behind, the superior Surface of which is relaxed in Inspiration, and becomes more plain, whereby the Cavity of the Thorax is enlarged, to give the Lungs more Liberty to be expanded by the Air, and the Viscera in the Abdomen to be compressed, for the Distribution of the Chyle. Whereas, in Expiration, the contrary happens, its Surface being convex, to lessen the Cavity and protrude the Air. A Wound in this Muscle is more fatal than one in any other, because so well stocked with Nerves, which it hath great Occasion of, by reason of its continual Motion, and being surrounded with several principal Parts.

The Muscles of the *Neck*, *Back* and *Loins* are seemingly very confused, tho' in great Order amongst themselves; and are these following. Those of the Neck on its back Part are, the Spinal, arising from the five superior transverse Processes thereof, and are inserted into its spinal ones: It seems to draw the Neck back. The second are the Transversal, which are a Continuation of those of the Back; they arise from between the oblique and transverse Processes of the Neck, and are inserted near the rest of the superior Spines thereof: They serve as the former. The next are the Interspinal, because they rise from the superior Part of each forked spinal

Of the  
Neck,  
Back and  
Loins.

spinal Process, except the uppermost, and are inserted into the inferior Part of all the said Spines: Their Use is to bring the said Processes nearer one another, and so to erect the Neck. To these we may join the Intertransversals that lie between the transverse Processes of the Neck, with the Intervertebrales, which do so between the *Vertebrae*.

Those of the Back are the the Longissimus, which serves to extend the *Vertebrae*, and to keep the Trunk of the Body erect, wherefore it is inserted all along, to the transverse Processes of the Spine, by a double Tendon into each. But besides this, there is the Semispinalis which arises from those of the six lowermost *Vertebrae* of the Back, and are inserted into the superior spinal Processes thereof. The next are the inner Transversal ones of the Back springing from the upper Part of the transverse Processes, and are fixed near the Roots of the spinal ones, passing over the next *Vertebrae* first.

The Mus-  
cles of the  
Loins.

The Muscles of the Loins, are the Spinalis, Transversalis, Quadrates, the Psoas, Parvus, and Intertransversales; an Idea of which may be framed from the former, which without a Sight of them, all that can be said will be but of small Service; for which Reason we forbear to say any Thing on those of the Head, as the Sple-

Splenius, Mastoid, Complexus, and Recti, with the two Pair of oblique ones that belong to its back Part, with those of the Pharynx, Larynx, and other Parts, which could but be a Repetition of what every anatomical Author abounds with; the best of which, every one knows upon this Subject, is the great Dr. *Douglafs*, and Mr. *Cowper*, in their exact Descriptions of the Muscles.

The Muscles of the Extremities are the largest and longest of any, for as much as their Parts describe the greatest Arches round the Centres of their Motion, as we see in the Biceps: Those that move the Hand round the Elbow, and those that move the Leg and Thigh; as the Sartorius, that hath its Origin so far distant from its Insertion, as the Os Ilium from the Tibia, moving the Foot in an Arch, whose Radius is at the Os Ischium. The reverse we see in those Joints that have but a small Motion, as the Muscles of the *Vertebræ* or *Interossei*, whose Arches described by their Motion are to those of the others, as the Length of one Muscle is to that of the other.

The Muscles of the Shoulder are the Pectoral, on the Breast, the Deltoides on the Tip of it; the Supraspinatus behind; the Infraspinatus below that; the Teres Major and Minor; the Latissimus Dorsi;

Of the  
Muscles  
of the  
Limbs.

Of the  
Shoulder  
and Arm.

U

the



Of the  
Hand,  
&c.

the Caracobrachialis; and the Subscapularis; all which are inserted about the upper End of this Bone, and give it its different Motions as one or the other is inflated. The Muscles of the Cubit or lower Arm, are the Biceps internus; Brachialis internus, which makes the fleshy Part of the upper Arm; and the Biceps and Brachialis externus, with the Anconeus, which is very little in respect to the rest. The Muscles of the Hand are Palmaris, Longus, and Brevis. Those of the Wrist are Flexor Carpi, Radialis and Ulnaris, with their two Antagonists or Extensors on the opposite Side. Those of the Fingers are the Perforated, and the perforating Muscles; where it is very surprizing to see, with what Art, the first four Tendons, that go to the second Bone of each Finger, are slit or divided about the Middle of the first Joint, for the free Passage of the Tendons of the perforans Muscle, which runs through their Fissures to be inserted to the third Bone of all the four Fingers. They serve to bend the two last Joints of the Fingers, as in grasping. Besides these there are small ones, called Lumbricales, which with the common Extensor of the Fingers, and little Interossei that lie betwixt the metacarpal Bones, and are inserted at the Root of the Fingers, give them their side Motion. To these belong

the

the Muscles of the Thumb, the fore Finger, and the little one, which they have proper to themselves, with the Pronators and Supinators of the Radius ; all which would be needless to rehearse ; only thus much we may remark by the Way, that those Muscles, which extend any of the Joints, lie on the Outside of it, and those that bend them are placed on the Inside thereof, as we see in the Arms and Legs.

The Muscles of the Thigh lie about the Hips, and are inserted about the Head of that Bone, some on the Inside, and some on the Outside. The first is the *Psoas magnus*, which I have cause to remember, being once very near loosing my Life, by a small Incision made upon my Thumb, whilst raising of it in a stale Patient, that was poisoned by the bad Juices that had soaked into it. It rises from the Body of the lowermost *Vertebræ* of the Thorax, and the Sides of all those of the Loins, and is inserted into the lesser Trochanter of the Thigh-bone : It bends the Thigh by bringing it forwards. The next is the *Iliacus internus*, and the *Pectineus*. The first from the internal Cavity of the *Os Ilium*, and joins with the former. The *Pectinalis* rises from the inner part of the *Os Pubis*, and is inserted near the other. All these serve to bend the

The Muscles of the Thigh.

Thigh inward. Upon the Outside of the Hip lie upon one another, the three Glutæi, Maximus, Medius, and Minimus; they all serve to extend the Thigh, by being inserted near one another, hard by the great Trochanter. Then is the external Iliac, which is inserted at the Root of the said Trochanter, and turns the Thigh outwards, as also does the Marsupialis, which rises from the internal Circumference of the great Hole, and is inserted where the former is. Then follow the Gemini, which arise from the Ischium, and are inserted into the Cavity of the great Trochanter, serving to turn the Thigh-bone outwards; between these two small Muscles, the Tendon of the former runs to its Insertion, to be guarded from being hurt by the Hardness of the Sinuosity of the Ischium, which it passes through, and also, as Dr. *Douglas* says, to hinder it from slipping out of that Cavity whilst the Muscle is in Action. The next are the Quadratus and Triceps, under which last are comprehended four distinct Muscles; for which, see the Author quoted in the Margin.

Vid. *Douglas's* Myograph. P. 140.

The Muscles of the Leg.

The Muscles of the Leg cover the Thigh-bone, and are inserted at the upper Part of the Tibia, and are eleven as those of the Thigh are sixteen. The first is the Membranous, which covers the

Out



Outside of the Thigh, it extends the Leg, and strengthens the Action of them that lie under. The Sartorius rises from the Os Ilium, and is fixed to the Inside of the Tibia, serving to lay one cross the other, and is the largest of any in the Body. The Rectus, Vastus, Externus and Internus, and the Cruræus, are all inserted tendinous into the Patella, and serve for the Extensum of the Leg. The next is the Gracilis from the Os Pubis, and is fixed to the Inside of the Tibia near the Sartorius, and for the like Use with it. The others are the Seminervosus, Semimembranosus and Biceps, arising from the Ischium, and are inserted into the Tibia and Fibula to bend the Leg backwards. The last is the Popliteus arising from the Edge of the Cavity in the lower Part of the external Condyle of the Femur backwards, must by the cross Ligaments; then running under the Ligament that involves the Joint, and adhering fast to part of the Cartilago Lunata, it becomes fleshy as it perforates the Ligament, and is inserted into the superior Part of the Tibia internally, its Use being to move the Leg obliquely outward, and to assist in bending the same.

The Muscles of the Foot are six. The extensor Tarfi Suralis; it is made up of four heads, the two outwardmost form the

The Muscles of the Foot.

Gastrocnæmius externus, and the two innermost the Gastrocnæmius internus; they arise, some from the Condyles of the Femur, and some from the back Part of the Tibia, and terminate at last in one large Tendon, which is inserted in the superior and posterior Part of the Heel-bone, their fleshy Bellies making that protuberance of the Leg called the Calf, which Projection, beyond the Os Tibia, occasions a considerable Distance between this Tendon and that Bone. The Middle and upper Part of these Heads of the two inner Muscles, between the Bones from whence they spring, is adorned with a tendinous Edge like an Arch, under which all the great Vessels belonging to the Leg securely pass: They serve to extend the Foot in bringing it backwards, and when these Muscles contract, they throw our Bodies upon our Toes, as we see in walking; for which Reason it is, that this Muscle consists of four Heads, which none other does besides it self; because it had need to be very strong, having the Weight of the whole Body to raise on the Toes, by means of the Foot, the Toes serving it as a Lever. And it may be observed, that great Walkers on low heeled Shoes, as the Highlanders in *North-Britain*, have generally large Calves, these Muscles being very large. Whence we may learn, that those who desire their Children should have handsome

some Calfs, ought never to suffer them to wear Cloggs; a Custom too prevalent amongst fond Mothers; but rather Shoes without Heels, or with a small Elevation under the Toes; and by exercising their Legs well, they will scarce ever fail of gaining their Desire.

Next to these is the Extensor Tarsi minor; its Tendon passes under the former, and is inserted a little below the Corda Magna, its Use being to assist the former. Then arises the Tibialis Anticus and Posticus, the first arising from the Tibia, and is inserted externally to the Inside of the *Os Cuneiform* to bring the Foot upwards. The other comes from the Appendix of the Tibia next the Fibula, and is fixed to the *Os Naviculare*, passing its Tendon through the Fissure at the inner Ankle; it brings the Foot inwards. The two last and sixth Pair are the Peronæus, Posticus, and Anticus; the first arising from the fore Part of the Head of the Perone, and passing its Tendon through the Channel of the inner Ankle; and likewise with the former and following it is reflected in the Sinuosity of the Calcaneum, and running along the Cavity, made in the *Os Cuboides* under the Muscles in the Soal of the Foot, is inserted into the Outside of the superior Part of the Metatarsus Bone of the great Toe, serving to move the Foot outwards. This is insert-



ed also into the upper and fore Part of the same Bone of the little Toe, and serves to pull the Foot and Toes outward.

Of the  
Toes.

The Muscles common to the four lesser Toes, are fifteen in Number, two Flexors arising from the Heel-bone, and the other from or near the Middle of the Tibia. The Tendons of the first divide like those of the Fingers, and give every second Bone of the Toes a Tendon to that Joint. The last is inserted into the upper Part of the last Bones of the lesser Toes, their Tendons having first passed through the Slits of the former; they serve also to bend the Toes. The two Extensors arise, the long one from the external Head of the Tibia, which dividing into four Tendons, two are inserted into the upper Part of the second Bone of each small Toe, together with the short one its Fellow, send off, for Frugality on both Sides, a small Tendon to the last Bone of the Toes, which unite a little before their Termination. The rest are the four Lumbricales, which arise from the Tendons of the Perforans, and are inserted by four small Tendons, into the Inside of the first Joint of the Toes, like those of the Fingers; and last of all are the seven Interossei, which have the same Situation with those of the Hand. They lie like a Bed of Flesh, between the metatarsal Bones, and are in-

serted

serted partly into the sesamoid Bones, and partly in the Sides of the Bones they belong to, and serve to move the Toes laterally.

The great Toe, like the Thumb, hath got its proper Muscles; as the Extensor and Flexor Longus and Brevis, Adductor and Abductor. So likewise hath the little Toe, its Abductor and Flexor, which see in *Cowper* on the Muscles. A Muscle common to both is the Transversalis Pedis: The Use is to draw the Toes nearer the great one, in making the sole Cavity of the Foot.

The twelve Muscles of the Head, and the eight of the Lips, with those of the Cheeks and Os Tryoids, Pharynx, Larynx, and the other Parts, we pass over, as being too tedious to mention in this brief Account, and to describe them at large, would be doing what is already done well to our Hands; therefore I pass to those of the Eyes as they have something particular belonging to them. They are six Pair in each Eye. The Elevator, which arises from the Edge of the Foramen Lacerum, near the Abductor, and is inserted into the superior and fore Part of the Tunica Sclerotis, by a thin Tendon: It lifts the Globe of the Eye upwards. Opposite to this is the Depressor, which arises from the lower Edge of that Hole, that gives Passage for the Optick Nerve, and is inserted into the opposite Part of the Coat of

Of the  
Muscles  
of the  
Eyes.

of the Eye to the former, serving to pull the Globe of the Eye down. The Adductor is from the Edge of the Hole in the Sphænoidal Bone, that transmits the Optick Nerve, between the oblique major and minor, and is inserted into the Coat of the Eye near the great Canthus: It draws the Eye towards the Nose, as the Abductor does from it, which arises from the Foramen Lacerum without the Orbit, and is inserted on the contrary Side, to pull the Eye from the great towards the little Canthus. These give all the direct Motions to the Eyes; but that they may have it in all Manner of Directions, there are two more Muscles, called the oblique Superior and Inferior; the first arising from the Edge of that Hole, through which the Optick Nerve passes, between the Elevator and Adductor, runs streight along the *Os Planum*, to the upper Part of the Orbit, at that great Canthus or Corner, where the Troclea is fixed to the *Os Frontis*, through which it passes like a Cord over a Pulley, and then alters its Direction, and turns backwards to be inserted into the Coat of the Eye, behind that of the Attollent: Its Use is to draw the Eye forwards, and to turn its Pupil downwards. The other oblique Muscle arises from the *Os Maxillare*, where it makes the Edge of the Orbit, and running obliquely



obliquely upwards, is inserted into the Sclerotic or external Coat of the Eye, between that of the Abductor and the Optick Nerve: It serves to draw the Ball of the Eye forwards, and to turn its Pupil upwards, as the ingenious Mr. Cowper hath rightly observed. The first are employed in Love Glances, and the second in Squinting; and both together, serve also as an Axis to suspend the Bulb of the Eye upon, for its free and easier Motion. But what is still very wonderful, is, the Mechanism of the superior oblique Muscle, and the cartilaginous Ring this oblique Muscle passes through, which is of so great a Use, that the Muscle could be of no Service without it; for it alters its Direction and makes it pull the Eye, as if the Muscle arose from the very Centre of the Orbit, where it could not do, there being no Room for it; besides were there Space enough for it to lie in, yet the Quantity of its Contraction from that Place, would not be sufficient to turn the Eye as required. Therefore Nature uses this mechanical Engine, the Pulley, from which Contrivance all these Advantages of this Muscle are exactly acquired, which without it could no otherwise be.

All the *Muscles* in general, and every one in particular, are very mechanically contrived; but amongst the chief, are those

Of the  
Muscles.

we

we have mentioned, and these few following. As the digastrick Muscles of the under Jaw; which arise from a Fulcus at the Root of the mastoid Process, and descending contract into a round Tendon, joined to a Ligament that comes from the *Os Thyroïdes*, and then become fleshy again, and ascend again towards the Middle of the Edge of the lower Jaw, where they are inserted, to draw the Jaw down, as in Gaping; which they do also by the Assistance of an annular Pulley, which alters the first Direction. It is double Bellied, for its fitter and more commodious Origination, and for the greater Length or Quantity of its Contraction or Motion. The Masseter is another Muscle of the lower Jaw; but one of those that pulls it upwards to grind the Food, and hath three several Heads or Origins, from the *Os Maxillare*, and Cheek-bone, which makes the Ball of the Cheek, and is inserted into the the inferior and external Part of the under Jaw, near the Centre of Motion, to act more forceably on the Molares, or Grinders, which it does, by moving a little forwards and backwards, by means of the above-mentioned Decussation. The parotid Duct passes over the tendinous End of this Muscle, and enters the Mouth near the Angle of the under Lip. In Brutes, this Muscle is all fleshy and

and hath no Tendon at all ; for which Reason, this Duct crosses not over it in them, least it should be obstructed, when the Muscle acts ; but, instead thereof, runs along the under Side of it in a parabolical Line, by which all Inconveniencies are avoided : And the Reason why it is tendinous in us and not in Brutes, is, because our Jaws being shorter than theirs, do not open so wide ; and therefore require not the Muscle to be so long to shut them, as theirs do. But as the longer the fleshy Part of a Muscle is, so much greater is its Quantity of Motion, it is requisite it should be all fleshy in them, a Tendon contributing nothing towards shortening of a Muscle, and besides their Food being more solid than ours, requires a greater Quantity of Saliva ; which this Muscle, by being all fleshy, at such Times presses out more abundantly.

The Muscles of the *Testicles* are two Of the Testicles. Pair ; one common and one proper. The last are called the *Cremasters*, and arise from the lowest and fore Part of the Spine of the Ilium, and are inserted into the external Coat of the Testicles, spread in several distinct Portions, serving to suspend, and to draw them up in Coition, to shorten the *Vasa Deferentia*, for the quick Passage of the Semen, into the seminal Vesicles ; they are but small, because



cause the Testicles not being heavy, do not require a great Force to lift them up; and being pendulous, if big, they would load themselves, and therefore they are pretty long; which is necessary, because of the Testicles hanging so low. The common Muscle is called Dartos, which is but a thin muscular Membrane of the Scrotum, which by the Action of its fleshy Fibres, contracts and wrinkles up, thereby assisting the former. In Persons very hot or sickly, it hangs long; whence Nurses judge of the Health of their Children.

Of the  
Penis.

The Muscles of the *Penis* are likewise two Pair; the first from their Office, called their Erectors; and the second the Accelerators of the Urine. The Erectors arise from the Tubercle of the *Os Ischium* distinctly, below the Beginning of the two cavernous Bodies of the Penis, and are inserted into their external Membrane, near their Union: They serve to draw the Penis up to the *Os Pubis*, thereby compressing the Vein, that runs along its Back and dewy Passage, to the reflux Blood, by which means that Member is erected. The second Pair are the Accelerators of Urine, arising from the sphincter Muscle of the Anus, and tendinous from the Ischium, and are inserted into the cavernous Bodies of the Penis, near from their Beginning to a little before their Union, and serve to compress

compress the bulbous and largest Part of the Urethra, both to drive the Blood into the Glans, and forceably to eject the Semen and Urine; those Muscles having Part of their Origin from the sphincter Ani, is the Reason why that is so closely constricted, when the other are in Action, that they might act the more strongly, which they could not do, did the sphincter Muscle yield to their Contraction.

The Muscles of the Parts of Generation in Women are those of the Clitoris and Vagina. The first hath two Pair. The first arise from the *Os Ischium* internally, near its Conjunction with the Pubis, and are inserted into the Crus or Beginning of the Clitoris, and answer to the Erectors in Men, both in Origin and Use. The second rise fleshy from the sphincter Ani and Perinæum, and run up the Side of Vagina near its outward Orifice, and are inserted into the Body of the Clitoris: The Use is the same with the former. The Vagina it self, Dr. *Douglafs* says, is furnished with two Pair. The first arise from the *Os Pubis*, and are inserted into the Vagina, to dilate it, and open the Extremity of the urinary Passage. The second rises from the same Line internally, and is inserted into the upper Part of the Vagina, at the Side of the urinary Passage, and serves to constring it after the Evacuation

Of the  
Pudenda.

ation of Urine. We purposely forbear speaking of the four Muscles of the Ear, Head, Nose and Lips, they being to be found in every Author : But to have passed by them all, without speaking of any, would have made this our Intension very imperfect.

## CHAP. XXII.

## Of the SKIN.

Of the  
fat Mem-  
brane.

**A**BOVE the Muscles lie the common Membranes or Integuments of the Body, viz. the *fatty Membrane* and the *Skin*. The first is a Covering of Vesicles full of an oily Substance, called Fat, whose under Side is red; it being there full of Blood-Vessels, and upon that Account, by some, hath been thought to be a distinct Membrane, and by them called the *Membrana Carnosa*, but falsely, it being only the membranous Part of the former. It covers the Muscles immediately, there being no such Covering for them as the *Membrana communis Musculorum*, as hath been likewise believed by some, who were led into that Mistake by the *Apaneurosis* of several Muscles. This fatty or adipose Membrane, I say, lies directly upon the Muscles, and immediately under the Skin,



its Texture being nothing else, but an infinite Number of little membranous Cells, on the red Part or membranous Basis of it, like so many Alveoli in the Bees Honey-comb, containing an oily Liquor, as was said before, secreted there by the fine Arteries that lose themselves in these fine Webs, and from thence is carried by small Ducts between the Muscles to lubricate them, for their free and easy Motion, and serves likewise to defend them from external Injuries, and give a Comeliness to the Body, over all which it is generally spread, except on the Lips, Scrotum, Penis, and Fore-head, where it is very thin, because otherwise, it would be so far from being useful, that it would be very heavy and cumbersome to them.

The next Covering upon the Fat, and the Subject of this Chapter, is the *Cutis* Of the Cutis. or Skin; in Brutes the Hide, which, as it consists of several notable Particulars, is worth while to consider them apart by themselves.

The Skin then is a membranous Ex- The Cutis panfion, spread over the Substance or Sur- what. face of the whole Body, under which all the Parts are wraped up, as under a common Membrane: And in it are placed the Nerves or Organs of Feeling, that nothing, at any Time, should assault our Bodies, without our timely Notice to prevent it.

What it  
consists of  
and its  
glandu-  
lous Part.

The proper Parts of which the Skin consists are three. That Part next to the adipose Covering, consisting of an infinite Number of very small Glands which separate Sweat and perspirable Matter, and send it off through the Skin by excretory Ducts; one of which, for that Purpose, arises from every single Gland. The Glands themselves are made by the fine Extremities of the evanescent Arteries, as hath been said of the others. So that as the Bowels or Viscera contain a Heap of Glands, under a common Membrane, determined to a certain Place or Part of the Body, the Skin is a glandular Covering spread over all its Surface, serving as a general Emunctory, to discharge peccant Humours, and the superfluous Serum and Salts of the Blood. These very emissary Glands, when obstructed, are the Cause and Seat of the Itch, Leprosy, and other such like cutaneous Distempers. Each Gland receives a Vein, Artery and Nerve, as the others do, and send out an excretory Duct, which passes through the two following Parts of the Skin to the Cuticle, to moisten the Extremities of the Nerves and Cuticle, and for want of which the Skin is rough, dry, and peeling, as in scorbutick and leprose Bodies.

The Reti-  
cular  
Web.

The second Remarkable belonging to the Skin above these Glands is, a Web of fine

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fine nervous Fibres, with other Vessels very nicely interwoven, and make, when wrought by an Artist, that Part called Parchment. This gives a Sense and Contraction to the Skin to guard out Cold, and other hurtful Qualities. It likewise squeezes upon the former, and often prevents an Obstruction, and removes it when it hath happened.

The third Part belonging to the Skin, and the Extremities of the former, are the infinite Number of *Papillæ* Pyramidales, that cover the whole Surface of the Body, and are the immediate Organ of Feeling, standing up perpendicular to the Plain of Nerves, and covered with two or three Caps or Coverings for their better Guard against their too tangil Subjects; betwixt these excretory Ducts of the milliar Glands open, making an infinite Number of Holes or Perforations very pretty to behold. Upon these *Papillæ*, or Points of the Nerves, is spread a fine nsensible mucous Covering, which, because it is peirced by them, and consequently full of little Holes, is, by *Malpighius*, called the *Corpus Reti- culare*, and serves to keep the Ends of these Nerves soft and moist, and distinct from one another, that they may be always ready for, and in Condition to receive Impressions from the slightest Touch.

Of the  
nervous  
*Papillæ*.



Whence  
the Black-  
ness of the  
Skin or  
other Co-  
lours.

It is this very Part in *Mores*, that gives the black Colour to their Skin, which in us is white or pale, and of different Colours in People of different Nations, and likewise in People of the same Nation, from the Nature of their Constitutions in which it differs a little. Now the Reason why this is so black in *Mores*, some say, is, because of the scorching Heat of the Sun, but though this may be Part of the Cause, yet it is not the sole one, by reason that there are some *Mores*, who live where the Sun is not so hot upon them, as in other Parts of the World, where white People inhabit, yet without this Effect upon their Skins. Therefore, together with the Heat of the Sun, we must take in the Nature of the Soil, which, by its vitriolick Effluvia, tinges their Rete Mucosum of that Colour; or otherwise it must proceed from the Quality of their Food or Diet, which, being so very hot, transpires vastly comminuted; Part of which is returned by this Membrane, and impresses on it that Colour of black, which is a peculiar one to Bodies who have their Parts mostly broken and porous. It serves to uphold the End of the Papillæ Pyramidal s Wherefore their very Tips just pierce it, so making it like a Cullender, or fine Net-work, with Holes, whence it hath its Name.

These

These three foresaid Parts constitute the whole Substance of the Skin; where we may observe, that the peculiar Parts that compose this fine Structure, are the very same, as those of the other Parts of the Body; namely, Fibres, Membranes, Arteries, Veins, Glands, and Nerves, only differently situated in respect of one another, and so produce the seeming vast Difference that at the first View presents itself; the Use of which is very great, and indeed as noble as any belonging to the Body: For here is the Seat of Feeling; for which Reason these Papillæ, or perpendicular Extremities of the Nerves, are more numerous in those Places which require a more exquisite Sense of Feeling, as the Palms of the Hands and Feet; and fewer where there is not so great a Need for them, as the Head, the Hips, and the like. Again the Skin serves to cloath the Body, to defend it from the Injuries of Weather, and to be a general Vent, for the superfluous Parts of the Fluids to transpire through; and lastly, to put forth and nourish the Hair, for the Defence and Ornament of those Parts. And as the Skin is a much nobler Part of the Body than what is generally thought for, and consists of several Particulars, it is the more liable to several Disorders, which its many Uses, together with its exposed Condition, makes it very obnoxious to:

The general  
Structure  
of the  
Skin.

Therefore, to provide against these, Nature hath bestowed another Covering over the tender Skin, which is it self insensible, and though very thin, yet able to bear and guard off external Injuries, without much Disturbance to the Body.

Of the  
Scarf-  
Skin.

This Membrane is called the Cuticle, and hath a very particular Structure, being not fibrous or membranous, nervous, nor glandulous, like the rest, but like the Scales of Fishes or Tilings of a House, consisting of fine thin Plates laid upon one another, which stick close to the Surface of the true Skin, to which it is tied, as some say, by Vessels which nourish it, though too fine to be seen. These Lays are thicker or thinner as the several Parts of the Body differently require; for in the Lips they lie plain, and only touch one another; but on the Ends of the Fingers, and Soles of the Feet, they lie thick, and are closely laid upon one another. It is commonly called the *Scarf-Skin*, and is that which is raised by Blisters; for this, being more dense than the former, it detains the ferous Matter, which the Skin squeezeth out when convulsed by the caustick Salts of Blisters, and, so being separated from it, forms a Bag which contains the Water. It is likewise very porous for the Transpiration of Vapours; but the former ferous Particles being too gross, and pressed out



out of the Cutis, faster than they can pervade the Pores of the Cuticle, they by Force separate its close Union with the Skin, and so forms a Cavity for the Water to lie in.

The Antients have differed much concerning the essential *Matter* of this *Cuticle*, some attributing it only to the Effect of the Air, that condenses the glutinous Matter which lies on the Skin; but that this is not true is proved from Abortives who have the Cuticle entire, though never before exposed to the Air. But it is more reasonable to think, with *Diemerbroeck*, that it hath a seminal Principle, as well as the other Parts of the Body; therefore it is, that the very Extremities of the fine excretory Ducts of the milliary Glands in the Skin, are here fastened or spread on the Surface of the Cutis, and hardened by the Air: And this is very agreeable to the Simplicity of Nature, which makes the one Part, to be the Continuation of the former, and never multiplies Distinctions, when a few Principles will do as well: I say, it is reasonable to believe, that these Scales are the said Extremities of the secretory Ducts, fastened in great Numbers and closely adhering to the Skin; as is the apparent Case in Fishes; and so in the Rising of Blisters, these Extremities being tore away from the main Body of their

The Matter of the Cuticle.

Ducts, their Orifices are wide and open, and spue out most plentifully, their Contents, between the Cutis and separated Cuticle, till the last is removed in dressing, and the Water removed; and then the Air dries and contracts these open Ducts again, which in a short Time protrude afresh, and form a true Cuticle, subject to the like Accidents.

*Its Use.*

The *Use* of the Scarf-Skin is, to defend the true Skin, which is of exquisite Sense of Feeling, from several external Injuries, both of Heat and Cold; and, secondly, to be a proper Medium between the Papillæ, or Extremities of the Nerves, and the Objects to be felt; that their Asperities might not grate too hard upon them, to their Hurt or Hardening; and, thirdly, to prevent, a continual Issuing out of the serous Humour from the Skin, as, we find when any of it is rubbed off a Part; and, fourthly, it conduces to the Beauty and Comeliness of the Body, by making it very smooth, and reflecting its different Colours in their true Lustre.

## CHAP. XXIII.

### *Of* EXTERNAL PARTICULARS.

**B**Y *External Particulars*, I mean those Parts, that come not directly under the

the Consideration of our preceeding Chapters ; and therefore have closed them here together in one, that no Part of the Body might escape our Observation. The first of which that we shall take Notice of is the Hair, which is spread up and down the Surface of the Skin ; but thicker in some particular Parts of it, and may be reckoned amongst the common Coverings of the Body, no Part being without more or less of it, except the Palms of the Hands, and Soles of the Feet.

They are long, small, thread like, dry, Its Description, and how nourished. hard, flexile Bodies, growing out of the Skin, of various Shapes, Diameters and Longitudes ; having each a large bulbous Root, whereby it is nourished, which lies pretty deep, to draw Matter for their Growth ; each Hair consisting of five or six others, wraped up in one common Tegument, or Tube, of several Figures, some, though but few, being round, some triangular, and most of them four square, like the Stalks of Plants or Vegetables.

They all grow as the Nails do, by that Of their Growth. Part nearest the Root, thrusting out that Part which lies immediately above it, and not by any Liquor, running along the Hair in Tubes, as Plants grow. But this is denied by some, who take the Hairs to be hollow Tubes, and to be nourished with



with Liquor attracted by their Roots, and conveyed through their Pores to their very Extremities, and use this as an Argument for it. If the Hair be cut, and made obtuse at the Ends, it would remain so, were they nourished by Protrusion from the Root; whereas the contrary happens, for as much as they become sharp again. Another they bring from the Disease they call *Plica Polonica*, where, upon cutting the Hair, the Blood flies out; and another from the Hair suddenly turning grey, and always beginning to do so first at their Extremities; with abundance more such like, which make nothing against the former Opinion; for the first is what will happen from a quite different Cause, than the passing of any Matter through the Hair to their Extremities, by the Air and the Friction of their Ends. The second is a Mistake, for that shedding of Blood is not from the Extremities of the Hairs themselves, but from a Distemper in the Skin near their Roots, which sheds Blood upon the least Motion on the Hair, and which, by trickling down their Bodies, appears as if it flowed out of them, whereas in reality it does not. And as to the further Extremities of the Hair growing grey first, is only for want of Heat, being the remotest Part from the Body, and most exposed to the Coldness of the Air, its former

former Nourishment being gross first, which disposes it to that Alteration. But not to add all I could for fear of being tedious, as this is the true Manner, how Hair is nourished, namely, by each Part near the Root shoving or thrusting out that which is immediately above, besides the former, I could bring Arguments from the Custom of Nature in other Things; for, wherever there are Vessels, they are either Sanguineous, Secretory, or Excretory; but the Hair is none of these, therefore not nourished like any of them. We shall therefore then conclude with *Gallen*, that their nutritive Matter passes not through them to their Extremities, but that their Growth is caused by the said Apposition of Matter to their Roots.

This being the Manner of their Growth, let us next enquire into the Matter of it. The Matter wherewith the Hair is nourished, says *Gallen*, is an Excrement of the third Concoction, and which is very true, though perhaps he did not know it so well as we do now a Days. For they are nourished by the animal Spirits or nervous Liquor, after it leaves the Nerves, and is of no further Service to the Body, the Thin flying off, as *Sanctorius* hath shewed us, and the Thick, as I take it, remaining in the Pores of the Skin, for this Use, and no peculiar Juice, to that

Of the Matter with which the Hair is nourished.

End,

End, specifically prepared in the Parts to be covered with it; for to this End there must be Glands, since there is no Secretion without them. Now the Hair hath no Glands; therefore their Juice must be secreted from those belonging to some other Part, which can be nothing else but the Excrement of the Succus Nervosus that lies in the Skin, and sticks to their Roots; thereby shooting forth by Degrees their preceding Particles, and so causes them to grow long. And it is plain and reasonable to think, this to be the most proper Substance for their Growth, seeing Water alone cannot serve, and Blood does not arrive at them; or if it does, is too gross to enter their Pores.

Of the  
different  
Colours of  
the Hair.

And this brings us next to account for the different Colours of the Hair, which depends much on the different Temperaments and Qualities of the Humours that nourish them; which Humours depend much on the different Climates the Person lives in. In short then, as I hate a tedious and round-about, or prolix Relation of Matters, the Hair in Infants is generally white, because their nervous Juices move but slow, and are the least comminuted of any Age; therefore the Hair, partaking of the Quality of its nutritious Matter, will reflect a white Colour, which is the one proper to Bodies of the greatest

Den-



Density, and the largest Surfaces, which is the Case of the Infants nervous Liquor. In the prime Age of Life, the Hair is either black, brown, red, or yellow, the two first and last being only from the different Degrees of their proper Cause. For if by the Circulation of the Blood, the nervous Juice will be well concocted, and well comminuted, and therefore the Hair will be black; or, if less broken, will be brown, the most common Colour in this Country. And black being a Colour peculiar to broken Bodies, whose Pores are so thick, small and ramous, as to absorb the Rays with Reflections, the Hair, in that Case, must partake likewise of the same Quality, and consequently reflect that Colour. Whereas in red and yellow the contrary happens; for there the nervous Juice is rank, that is, gross, and of large Size, the perspirable Matter less broke than the former, which makes it fit to reflect the red Rays from it, rather than any other. But if these Causes all act in one Body, and in different Parts of the Skin, then the Hair shall be of various Colours; and not only in the Hair, but even the Skin of that Part, from the extravasated nervous Liquor of that Place; as we see in Dogs, Pigs, and Horses of speckled Colours; which, when they grow old, by reason of the abated Vigour of the Heart, and consequently of the Blood

too, the nervous Liquor grows grosser than to make black Hair, or even red, it causes it to grow grey, and afterwards, the Spots that were black before grow white.

Hence it is very apparent, why the *Egyptians, Arabians, Indians, Spaniards* and *Italians*, are generally black haired; by reason they inhabit hot Countries, and are much used to strong Wines and hot Diet; whereas the *English, Hollanders, Scotch, and Danes*, are generally bright haired, because they inhabit colder Countries, and perspire less, and what they do is not so greatly broken and grownd by the Action and Attrition of their Solids as the former.

Whymore  
Hair in  
some Parts  
than in o-  
thers.

The next Thing to be enquired into is, why some *Parts* of the Body abound with more *Hair* in than others do; and which, by the by, will let us into the Reason why Women have no Beards. We have said, that the Substance of the Hair is the excrementitious Part of the nervous Liquor, which nourishes their Roots, whence one would think, that as all the Body perspires, Hair should be alike spread upon it, as we see it is in Brutes; but let it be known, that besides this perspirable Matter; there are some other Circumstances to be considered in accounting for this Phænomenon, and that is the peculiar Disposition of those Parts, for its abundant Growth.

Now

Now the Hair breaks through the Pores of the Skin, yet not through all of them, but only such as are endowed with a certain Aptitude to suffer their Eruption, which is out of those Angles which are formed by the Intersections of the parallel Fibres of the Skin, that by crossing one another, make Spaces of a rhomboidal Figure, out of each Corner of which arises a single Hair, but in the Palm of the Hand and on the Ends of the Fingers, where they do not intersect one another, no Hair grows. Whence we see, that for Hair to grow thick and plentiful, the Skin must be very porous and spongy, to detain the perspirable Matter in, or else it will flie off, as in Women, and not nourish the Hair; and to confirm this Opinion, we find, from the same Reason it is, that Dogs and Foxes are so thick covered with it, and so long; because they perspire but very little, their Skin being thick, oily and spongy, retaining the perspirable Matter in their cellulous Hide; and this makes them so subject to the Mange, and to run mad in Fevers, for want of a quick Discharge, through the Pores of the Skin, by Perspiration and Sweat, as we have.

Now for the producing a greater Quantity of Hair in one Part of the Body, than in another, there are two Things necessary. First, a strong and large Perspiration;

Why Women want Beards.



ration; and, secondly, a particular Structure and Sponginess of the Parts, which is the chief Reason, why the Head, Arms, pits, Pubes and those Parts have it so long and plentiful; when the Belly, the Back of the Hand in tender Persons, and the Inside of the Thigh have but little of it, and very short. Whence also we may find out the Reason or Cause, why a Man hath a Beard, and a Woman none, in as much as the Man perspires more; therefore in them the nutritious Substance of the Hair is more plentiful, and likewise their Skins are more porous and spongy than the latter, and therefore detain the nervous Juice from flying through it so quick, which must then be converted into Hair, and so you have a Beard in one and not in the other; the final Cause of which is for distinguishing the Male from the Female, which without it could hardly be known, were they both dressed in the like Cloaths. And if there is any one that will not believe this, let him feel and compare the Roughness and Porousness of their own Beard, and the Chin of a Woman, and their Feeling will inform them, there is a great Difference in their Textures.

From hence likewise we may learn, that the more a Person perspires, the rougher of Hair he is, and thence *Levi-*

*nus Lemnius*, and others, affirm a Man to be the stronger, for having a great Quantity of it, whilst others again deny it: But though a large Quantity does not always denote a Man to be strong, because often the contrary is found; yet a small Quantity of it demonstrates the Person to be weak. Whence it happens, that in effeminate Men, who evacuate their menstrual Superfluities more by Urine than Perspiration, as *Sanctorius* says, have a lesser Quantity of it, and that what they have is very fine and soft like the Female Sex, and even to the Wanting of a Beard in some.

Vid. *Sanctorius's*  
Med. Static. P. 82.

Another Remarkable belonging to the Hair is, its being lank or curled, which proceeds from the different Degrees of Heat they suffer; for in cold Countries, the Hairs are streight, and in hot curled; so in Men, Bulls, and other Animals, more curled, than in Females of those Kinds; and this Heat also makes the Substance of the Hair perspire more on one Side than the other, whereby it shrinks up in that Part and forms a Curve.

Lastly, *Baldness* is another Phænomenon Of Baldness. belonging to the Hair, and further confirms our Hypothesis concerning it. It is a Falling off of the Hair, on the fore Part of the Head, common to Men in Years;

Y

and

and proceeds from Want of Heat in that Part, because there are no Muscles nor Fat to keep in the perspirable Matter ; and so the Cutis becoming dry and cold, the Hair, for Want of proper Nourishment, falls off; and the rather here than on the hind Part, because the Cause is stronger.

Of the  
Arms.

Other Particulars belonging to the Body are, the *Arms* and Legs, framed of the common constituent Parts with the rest of the Body; viz. Cuticle, Skin, Fat, Muscles, Nerves, Arteries, and Veins, only differing in their Figure and Uses. The Arms lying parallel with the Sides of the Trunk, are able to move round the Shoulder, describing a whole Circle, and assist us thereby very much to run, and serve us to defend the principal Parts. At their Extremities they are divided into lesser Portions, called Fingers with several Joints, and of different Lengths, the many Uses of which are not easy to be enumerated. They are many to lay the better hold of any Thing, and of different Lengths, to make them act equally, and direct their Forces in the Centre of the Hand. They are strengthened with Nails, which serve for Defence and Ornament, besides several other necessary Uses, which may be seen

Vid. Ray in Ray on the *Creation*.  
on the  
Creation,  
P. 278.

The Nails are a hard, transparent, horny Substance, analogous to Hoofs in Horses and



and other Animals, and are nothing else but a Number of small Husks, which answer to so many Papillæ of the Skin, and are the very Caps, Covers or Sheaths of those Papillæ, dried and hardened on the Extremities of the Fingers and Toes, lying close upon one another, and are nourished by Apposition of nervous Juice at their Roots, which protrudes them by Degrees, so that we have about five or six new Nails in a Year, the former being wore by using.

The *Thighs* and *Legs* stand from the Body in the same Direction, and have the Motion of a half Circle round the Centre of Motion in that Joint. Their Use, every one knows, is to serve us to stand upon and walk erect: For which Reason they are furnished with great and strong Muscles, above those of the Arms or any other Part. They have each a Foot or Basis to stand firm on, with Toes to assist them in Walking, and which is performed, by throwing our Body upon the one, whilst the other is carried by Muscles a little forwards, and then throwing the Weight of the Body, or its Centre of Gravity within the Bounds of that Foot, till the former is brought from behind and placed a little before to receive it from the other afresh, and so by this repeated Motion we are enabled to move from Place to Place

Of the  
Thighs  
and Legs.

at our Will. In standing both our Feet are used, and then the Centre of Gravity falls between our Legs; but if the Direction of the Centre of Gravity, is, by any Cause, thrown either on one Side or the other, Before or Behind, without the Compass of our Feet, our Bodies will follow that Direction, till Gravity throws it down upon the Ground, or its Weight makes it fall. This is the Manner how two-legged Animals perform that Action of Walking, which by the Instinct of Nature and Custom they are all able to perform, in such Directions as are most fit for their secure moving.

How Flies  
move.

In *Flies* that have three Pair of Legs, I have observed, that they guard themselves against falling, when they whet their two hinder ones, by throwing the Centre of Gravity of their Bodies, on their two anterior Pair before, which they set at a greater Distance from each other than before; and the contrary, when they whet them; but when they whet their middle Pair, they do but one at a Time, and by the two Posterior forming a Triangle with the odd one of the Middle, and the two anterior Legs; and so of the other Side.

Four-  
footed  
Animals.

For this Reason also it is, that all *four-footed Animals*, when they walk, move the

the fore Leg, and the hind Leg of the contrary Side, so intersecting the Line of their Directions, which is called trotting ; and for this Reason, Geese always stoop going in a Barn-Door, to ballance their Body ; as if nature had taught them that Part of Mechanicks, that teaches the Action of a Weight to move a Lever at so much the greater, the further it is removed from the Centre of Motion ; or what is all one, by making one Brachia of a Ballance, longer than the other, without adding any more Substance to it, it will, from the same Law, over ponderate the short Brachia, in the same Proportion as the Spaces gone through by the different Arms of the Ballance ; that is, as the Arch, which the long Arm describes round the Centre of Motion, is, to that which the short one does, so is the Weight of the Arm to that of the other. To apply this to Geese, and other short-legged Fowls, when they offer to step over any Threshold or rising Ground, in lifting up their Breasts, the Centre of Gravity of their Bodies falls backwards, behind their Legs, their hinder Parts, in that Position, being heavier than their fore Parts ; therefore to recover this, and restore the Centre of Gravity in the Middle of the Body again, they stretch out their Necks and stoop down their Heads, and thereby



throw the Centre of Gravity more forwards, and so are able to mount up, by the said mechanical Advantage of removing their Heads further from the Centre of Motion in their Bodies, which, like the long Arm of a Ballance, weighs up the lower End.

But such Fowls as have long Legs need not this Contrivance, because by making their Legs to form different Angles, they can keep the Centre of Gravity within the Compass of their Feet, without the former Assistance which is peculiar to short-legged Fowls, or such as are made for the watery Element, to whom long Legs would be cumbersome in Swimming.

Of the  
Face.

Again, the *Face* is furnished with many Particulars, as the Eye-lids, the Eye, Nose, Lips, and Mouth, with several others too long to mention; all made up of Membranes and Vessels like the other Parts; but differing in Shape and Situation, which makes them differ in Use. The Eye is a most curious Part of the Body, made convex the better to contain its three Fluids, and for its quick and easy Motion. It is commodiously situated in a secure Socket of Bone, well guarded, on all Hands, from external Injuries, with a fine membranous Curtain before, to cover it when not in Action, and to wipe it clean,

clean, if Dust, or any extraneous Body, happens to annoy it, and also to spread the Lymph of the lachrymal Gland equally upon its Surface, that it may not become dry, from the Action of Air upon it. And still, for their better Security, these Lids are cartilaginous at their Edges, to meet the closer with each other, and to slide the better on the Eye, without wrinkling or folding together, and so keep them extended, that every Part may be equally raised. Upon them is a Rank of small Glands, whose excretory Ducts open upon the Edges of the Lids, which secrete a Wax or glutinous Matter, to fasten them together whilst one is asleep. They have three Coats, as all other Parts have; the External is the Skin; the Middle is Muscular; and the Internal comes from the conjunctive Coat of the Eye. They are likewise guarded on their Edges with long Hairs, like Pallissadoes, to preserve the Eyes from having Filth or Flies falling into them; as likewise is the Use of the Eye-brows which lie above them; besides, to break the Rays of Light, when too strong to enter the Eyes direct, that Vision may not be dazzled with their too strong Impulse.

The Eye being thus guarded is it self composed of Coats or membranous Coverings. The first the Conjunctive, which

Of the  
Structure  
of the  
Eye.

makes the White of the Eye by its tendinous Part. It joins the Ball of the Eye to the Edge of its Orbit; thereby preventing any Thing passing behind it, to disturb its Motion. The second Coat is called Sclerotica; it is thick, hard and smooth, and opake, excepting before, where it is transparent, for the Admission of the Rays of Light. This transparent Part makes its third Coat, called, from its Resemblance to fine transparent Horn, Cornea. It is more convex than any other Part of the Eye, and composed of several parallel Lamina, nourished by such fine Blood-Vessels as are imperceptible; but I rather think, by its Nerves, there being but small Occasion for the other there. It is exquisite in Feeling, to give timely Notice to shun any Thing that in the least can hurt it, and that the Tears might be squeezed plentifully out of the lachrymal Gland, to wash off any Filth or Dust, that might render it opake. The fourth is the Choroid, which lies within, and is much thinner than the former: It abounds with many Blood Vessels which come from the former, and is lined also with many Glands, composed of them; which separate a black Liquor to daub its Inside, which otherwise is of a whitish Colour on purpose to obsorbe all scattered Rays, to prevent Confusion of Vision, as the Case of Owls, who



who cannot see clear in the Day. The fore Part of this Coat is open, and is reckoned the fifth Coat of the Eye, and is called the Uvea, made of streight and circular Fibres, for its Dilation and Contraction, as the different Quantities of the Rays of Light require. The Iris, or Rainbow-like Part is its Outside, of different Colours, from the different Constitution and Heat of the Body. On its Inside, from its Circumference, which joins the choroid Coat, rises the ciliar Ligament, made of short Fibres, which run upon the fore Part of the glassy Humour behind, to the Edges of the Chrystaline, which lies in the Middle, like so many Lines drawn from the Circumference to the Centre, and seem to modify the Eye so as to behold Bodies at different Distances, by making, when they contract, the fore Part of the Eye more prominent, and removing the Retina further back from the chrystaline Humour, when Bodies are placed too near the Eye. To this some add, the Compression of the Muscles of the Eye, in altering the Form of it, in viewing Objects at different Distances, but how true it is I cannot say, so that Whales have no such Benefit, the Coats of the Eye being impliable, like hard Horns. The sixth Coat is the Retina, so called, because it is spread on the Back of  
the

the Eye like a Net, and is a fine Expansion of the medullary Fibres of the Optick Nerves upon the Surface of the glassy Humour, as far as the former Ligament; which glassy Humour fills up all the Posterior, half of the Globe of the Eye, receiving into its fore Part, a small Dint from the Chrystaline one, that is solid and convex on both Sides, which lies before the Pupil, and serves as a Lens to converge the Rays, and make them come to a Point or Focus on the Retina, which is the Seat of Vision. And to keep it clear from all other Bodies, there lies a Water before it, called the aqueous Humour, of a spirituous Nature, and secreted by some Glands, placed there for that Purpose; for if it is exposed to the greatest Frost it will not freeze, and if let out, will soon fill up again.

These are the chief Remarkables belonging to the Eye: Its six Coats and three Humours. As to Vision, and its more minute Particulars, I wave them, as being in every Author. Only here we must observe, that it is wholly performed on the Retina, whose fine Fibres, being moved by the Rays, and their contained Fluid, put into an Ovation by their Impulse, imprints that Sensation on the Sensorium in the Brain, which we call Sight. For any further than the Motion of the Succus  
Ner-

Nervous, we know nothing what Sensation is. Some have even denied Vision to be performed upon the Retina, but say it is upon choroid Coat, as Monsieur *Marriotte* observes, because where this Coat does not cover the Eye, Vision is there quite lost, as the Case is, where the Optick Nerve enters it, and which is about 25 Degrees from the Axis inward, near the Nose, that it may be mostly out of the Way of the Rays falling upon it; because, there they are all lost, which may be caused, not for Want of the choroid Coat in that Part, but from the Strength and Closeness of the Fibres of the Optick Nerve, that can receive no sensible Impression from the fine Rays of Light, when they fall upon the Entrance of the Optick Nerve.

V. Hook's  
Lectures  
upon  
Light, P.  
123.

The Eye can see nothing, under a much less Angle than a Minute, or the sixteth Part of a Degree, or the 21600 Part of a Circle; therefore, whatever is sensated or seen by it, is seen of that Bigness or under that Angle; and in such Cases, Microscopes helps us in Objects near, and Telescopes in those afar off, by encreasing the Angle under which Bodies are seen, and which belongs to another Head. But Vision in general, is performed by the Rays of Light that flow from a visible Object in straight Lines, and, entering the Pupil,

Vision,  
how per-  
formed,  
and how  
far ex-  
tended.



Pupil, are conveyed or brought closer by the refractive Power of the chrystalline Humour, which is placed there on purpose. Thence they pass through the glassy one, without any Alteration, but Distance, where, at last, they all concur in one Point, called by Opticians, the Focus, upon the Retina, and there lay down the Picture of the external Object in a perfect Draught in Minature; each Particle of Light, or Extremity of a Pencil, or Beam of it, rather touching a certain Point of the Retina, which, as *Des Cartes* says, being like a Piece of Plush, with the Ends of the Threads, turned towards the chrystalline Humour, and all their other Ends terminated in the Brain, does impress a Motion on every Fibre, which is received by the elastick nervous Juice, and by it reverberated to the Sensorium; which, when the whole Picture of the Object, is smaller than one of these velvet-like Fibres of the Retina, it cannot affect or move a less Part, than one of these small Threads or Filaments; therefore, the Sensation is the same, as if the Object did take up or cover the whole End of the Filament, though it affects but the tenth Part of it, provided it is strong.

Why the  
Sun and  
and Moon  
appear  
largest  
when they  
rise.

Now though the common Proverb says, That seeing is believing; yet there are several Cases, wherein our Sight deceives us, and which

which we have a remarkable Example of, in respect of the Sun and Moon, which appear much greater upon rising or setting, than at a greater Height, though, as it is well known, their Pictures on the Back of the Eye, are as small then as when they are in the Zenith; and that of the Moon, is actually less, when it appears near the Horizon. Therefore, this is false Vision, and occasioned by the Interposition of the Fields, or Surface of the Earth, whereby we judge the Idea of Distance with the Encrease of Magnitude, which is necessary for making a true Judgment of Magnitude in other Cases, and so the Ideas are so closely joined, that they cannot be separated, not even in those Cases, in which we know that they lead us into Error. And even so would any other Body appear of a different Magnitude, if applied in these two Directions, the one Parallel to the Plain of the Horizon, and the other Perpendicular to it. And that this is the Reason of it, is plain, by looking through a Tube, and then this apparent Distance vanishes, as also the Magnitude which is deduced from it.

Vid. *Gravesand*,  
P. 67.

Another admirable Phænomenon belonging to the Eyes, is their being double, and yet seeing all Objects single; the Reason of which is hard to say. Some think it proceeds from the Meeting and Union of

Why Objects appear single tho' received by both Eyes.

of the Optick Nerves, but how that should do it, is difficult to conceive, because they do not mix themselves with each other; and besides, Fishes, in which they do the same, do not see single, each Eye viewing a different Hemisphere, they being in them situated on each Side of their Heads. And this single Vision happens only, when the Object is painted in correspondent Points of each Retina; for turn one Eye a little a wry, and you shall see Objects double. Some again say, it is only Custom, and that all Animals see double, when first born. But this is hard to prove, none remembering how they saw to give an Account of it. But if it may be excused, I think, the Optick Nerves must have a Communication with one another at their Beginnings, which Point of Union represents the Object single to the Sensorium, so that as the Rays that impress the two Pictures of a single Object on the two Eyes, come from one single Point or Object without, so they meet in the Brain again, and form a single Point there before they affect the Sensory.

An Ob-  
jection  
answered.

But against this some may ask, How then can the altering of the Position of one Eye cause us to see double? I answer, Because there is a correspondent Union between every Fibre of the Retina; which makes it necessary, that they only should be



be affected by the same Points of the Object, which if you change, that Motion which should be the same in those Fibres of one Eye, with their correspondent Fibres in the other, it is altered; and therefore, another Impression is put upon them, and consequently a double Idea in the Mind; two different Motions in the correspondent Fibres of the Optick Nerves concurring at the Point of Perception, which are distinctly received by the Sensorium, thereby forming the double Idea of one Object.

Again, To confirm this, we find, that only one Point at a Time can be seen distinctly, *viz.* that which is represented in the Axis of the Eye: Wherefore, if we look at one Point with both Eyes, we must so direct them, that their Axis shall meet in that Point, which always happens, when we have our Eyes intent upon any Point.

And by this Direction of the Axis, or the different Angles they make, we judge of the Distance of Objects; therefore, as long as the Distance of the Eyes, bear any sensible Proportion to the Distance of the Object, we can judge of it pretty certainly.

But to see an Object distinctly it is necessary, that its Picture should be laid down upon the Retina, by the Rays which

Distinct  
Vision,  
how per-  
formed.

are

are reflected by that Object, and in which they must all concur in a small Point or Focus; for if the Rays coming from the same Point, are not exactly united upon the Retina, its Picture is not a Point but a Spot, which is intermixed and confounded with the Pictures of the neighbouring Points, wherefore that Vision will be confused; therefore, to remedy this, the chrysaline Humour, which brings the conveying Rays to a Point, is by the muscular Fibres of the ciliar Ligament brought more forwards, when we view Objects near, and is removed more backwards, in them at a Distance, that it may hasten or retard, this concurrence of the Rays in a Point, and make them unite in both Cases, just upon the Retina. Wherefore, in old People, from the Flatness of the Cornea, and other Alterations in their Eyes, the Rays are not so strongly refracted, as in former Years, and therefore the Rays of near Objects, fall upon their Retina, before they form a Point or Focus, and they see Objects at a Distance much better, by reason of their Rays entering their Pupil more parallel, and consequently require a less Degree of Refraction to make a Centre in a Focus; whereas the very contrary happens in the Purlind or Myopes; for by Reason of the over Convexity of their Eyes, they see near; but their Refraction

fraction being too great, makes the Rays arrive at a Focus, a little before they touch the Retina; when, as it is always usual, they diverge again, and so fall upon the Retina as confused, though from a quite different Cause than those of the former; therefore Spectacles, or convex Glasses, will remedy the former, and concave the latter.

A Body or Point, always appears more enlightened, the greater Diameter of Rays flowing from it, enter the Eye; because their Motion agitates the small Fibres of the Retina so much the stronger, by which Agitation, the Idea of the Object painted on the Eye, is excited in the Mind, the Connection of which, as we said before, is utterly unknown to us, in accounting for all Sensation, not being able to go any further than the Agitation of the Nerves, and their elastick Fluid. And therefore we cannot understand the Reason, why, though all Pictures on the Retina, by Reason of the Intercession of their Rays, as they pass into the Pupil, are inverted; yet we see always the Object erect; by Reason we have no Notion of that Connection between an Idea in the Mind, and an erect Figure, or yet of an inverted one; but Experience teaches, that there is one; but how it is we do not know, except you will hear my Notion of the Matter.

How the  
Sensory is  
differently  
affected.



ter. If this is any ways caused by the Nerves, it must be by those Filaments of them, that are spread on the lower Part of the Retina, ascending above the other that answer to the superior Part thereof, as they enter the Brain; and the Arraignment of Impulses in each and every nervous Fibre, being, as before, only inverted, the Image may strike the Septum Lucidum or common Sensory with an erect Impulse; or else you must allow the Nerves to form a Curve behind the Sensory, and so, like a Wheel, to turn up the Image then, that is inverted on the Eye, and so impress the Motion of an erect Figure; which is indeed erect in that Condition. But if you will not allow of any Disposition of the Nerves for this Phœnomenon, nor natural Cause, then it can never be accounted for.

To pass by many Particulars belonging to the Eyes, as the perpendicular Direction of the Pupil, in Cats, to the Plain of the Horizon, because their Prey being Birds that Inhabit the superior Regions, as well as Mice below, Nature hath figured the Hole of their Eyes so, that they may have a greater Space in those Directions, under their View; and besides, the Back of their Eye, under the Retina, is white, that they may discern the Mice the better in the Night Season; whereas in Cows the

the Pupil is a-cross the Eye, that they might view a large Compass laterally, and the Back of their Eye is green, to discern their green Food the better when dark. But in human Bodies the Pupil is round, because we have occasion to direct our Sight equally alike every where, and the Back of our Eye is black, that we may see the more distinctly in the Day-time, the Bed being appointed for us in the Night-season. In some the Pupil is large, and in some small; the Owl is subject to the first, which is the Reason she cannot see in the Day-time, because so many Rays enter her glazing Eyes, as to dazle her with their over Brightness. But we have it suited for all Occasions; it being able, by its muscular Fibres, to open wide in the Dark, or where Light is not very powerful, and to contract very small, when it shines bright upon it, to let no more Rays enter, than what the Retina is able to bear with their Impulses; wherefore it is, that when one comes out of the Light into a Room a little obscure, we think it very dark, till such time as the Pupil hath dilated it self suitable for the Quantity of Light in it; and so likewise, after going out of the Dark into the Sunshine, the Eyes cannot, at the first, endure it, till they have had some short time to contract, and fit their Pupils to

admit it proportionably. Again, another common Phænomenon of the Eyes, is the dazling and sparkling Rays that seem to Dance before our Eyes, at some certain times ; especially before a Candle lighted, and proceeds, as *Bobault* says, from some watry Particles, which happen to lie in too great a Plenty on the lower cartilaginous Edge of the Eye-lids, that refracts the Rays of the Candle, and makes them appear, as if all dancing in the Air.

Of the  
Structure  
and Use  
of the  
Nose.

The *Nose* is a Covering to the Perforation in the Face, which would have been but uncomely without it. Therefore it is Bony at its upper Part, for the better Defence ; and cartilaginous below, as most convenient for Dilatation, Contraction and Vibration. It hath two Nostrils rather than one, because the Nose would not keep up without its Septum, nor would the Voice be so pleasant ; the Nose being like the Hollow, and the Septum like the Bridge of a Violin, as appears in them that quite want their Nose, who have their Voice but very imperfect and disagreeable, the Air rushing out, with but little Resistance, and the Sound presently vanishes. The upper End of each Side of their Cavity divides into two, of which one goes to the spongy Bones, to convey the Air, impregnated with odoriferous

rous



rous Particles for Smelling; and the other goes down to the Fauces or Jaws, and opens behind the Palate, by which we breathe through the Nostrils. The upper Passage communicates with the frontal Sinus, which is a large hollow Cavity, between the Duplicatures of the Bones of the Eye-brows, lined with a fine Membrane, as the spongy Bones are, and beset with many Glands, which distill a Liquor to keep them moist, and is afterwards carried down into the Nostrils, for the moistening of the Membranes of it also, which would dry up and grow hard, by the Air always acting upon it. The Use of the Caves or Cavities is to collect and detain the fragrant Particles, that they may the more forceably strike the olfactory Nerves, which are but very weak and fine, and much soaked with Water. The Bigness and Shape of Noses differ much, according to the Constitution of the Person; for a large long thin Nose, denotes the Nerves to be large, and lax, and the Brain soft and moist.

The *Mouth* is a large Peforation of the Skin, to admit Food and Air; guarded with two Lips to keep it shut, and to assist in eating or speaking; for which they have several Muscles inserted into them, for their several Motions, and greatly assist Children in sucking. The Palate, or Roof of the Mouth, is made up of the proper Bones,

Of the  
Parts and  
Uses of the  
Mouth.

Bones, with those of the upper Jaw, covered with a thick Membrane, which is continued to the Tonfils, upon which are a great many Glands, whose Ducts pierce it like a Sieve, discharging their Liquor into the Mouth, to moisten the Aliments, and forms the Uvula, which is but a Production, or Duplicature of it, and serves to form the Voice, and assist in swallowing.

The Parotid Glands.

Besides the former little scattered Glands, and those that line the Inside of the Cheeks and neighbouring Parts, there are those called the Parotid ones, situated on each Side, under the Ear, above the Masseter Muscle, and are a Collection of Lymphatick Glands, each of which send out a Duct, which, all uniting, form one single Channel, called *Ductus Salivalis Superior*, which running over the Cheek, pierces the Buccinator and opens into the Mouth. The other are the Maxillary Glands, which lie within the under Jaw on each Side; whose excretory Ducts, both together, open under the Tips of the Tongue, where they have each a small Papilla, at their Orifice, to keep them open and clear. The third Sort are the Sublingual, one on each Side of the Tongue, and open like the former, and just by them, with which, sometimes, they join: An Obstruction of these Glands is called Ranula. The fourth are the Ton-

fils

filis or Almonds, placed on the Sides of the Basis of the Tongue, under the common Membrane of the Fauces, with which they are covered. Each of them have a large oval Sinus, which opens into the Jaws; and in it are a great many lesser ones, which discharge themselves through the great one, into the Fauces, to moisten and lubricate those Parts. These all serve, upon the Action of those Parts, and the Compression of the Muscles, to emit large Quantities of Spittle, to dissolve the Aliments, when the Teeth grinds them.

The *Teeth* are the hardest and smoothest Of the  
Teeth. of any of the Bones, and are formed in the Cavities of the Jaws, which are all lined with a thin fine Membrane, upon which are many Vessels, through which there passes a thick transparent Humour, which, as it increases, hardens in the Form of Teeth, as may be seen in the Jaws of Abortives. There are about thirty two in all, and harder than other Bones, because their Attrition is much greater, and constantly keep grinding, to recruit what is daily wearing by their Action. About the seventh Month of the Child's Age, they cut the exquisite sensible Periosteum, which covers them, and the Gums; thereby causing all those Symptoms that attend their appearing. They are divided into the eight Incisores, or Cutters, which spring



out first, because thinner and sharper than others, and serve like so many Wedges to cleave the Food with; those of the upper Jaw first, because of the Assistance they have of their own Gravity, and the stronger Propulsion of the Vessels, Next are the four Canini, because sharper than the Molares, and thicker than the former, and serve to hold fast by, and hinder the Food from falling out of the Mouth. Last of all come the Molares, or Grinders, twenty in Number, and which are very flat and rugged, having a double Incision or Furrow, which intersect each other at Right-Angles, on purpose to adapt their Surfaces, to tear and grind asunder, the adhereing Particles of our Food. The Teeth, as far as they stand out above the Gumms, are well lined with a particular hard Substance called the Enamul, which serves to defend them from the Injuries of the Air, and acrimonious Juices; which fine glazing when they chance to loose, they begin directly to Rot and Corrupt; for which Reason Pins are improper Tooth-pickers. Their Substance at the first, is a clear viscous Liquor, of which there are two Lays one above another; and as the lower grows, they thrust out the Upper, and so cause the Shedding of Teeth, which happens about six or seven Years of Age, and are not a Shedding a Branch of the old Root, which  
springs

springs afresh, as *Diemerbroeck*, and others, have thought.

Lastly, within the said Cavity lies secured on all hands, the little noted Member <sup>Of the Tongue.</sup> the *Tongue*, than which there is not a more needful, or mischievous one belonging to the Body.

The Tongue is a Congeries of muscular <sup>Its Description and Use.</sup> Fibres variously interwoven, and inclosed in two Membranes, besides the Cavity it lies in, which answers for a third. Its external one is well stocked with Papillæ of a Pyramidal Figure, inclined towards the Basis of the Tongue, particularly near its Tip, and most evident in Brutes, in some of whom they grow cartilaginous. Each hath a small Root, which makes a small Hole in the Peter Mucosum or viscus Substance, which is contained betwixt the two Membranes. They serve to mix our Food, and to detain the finer Part a little to soak into the Pores, for our better relishing it, and to guard the Pyramidal Tips of the gustatory Nerves.

The mucous Tunicle is white, on that Side next the external Membrane, and black on that Side next the internal one, which, when the Tongue is boiled, hardens, and looks like a Sieve full of small Holes, made by the Roots of the former Papillæ, which are but so many Productions of the outward Coat. The inner Membrane is fine and

and soft, upon which appear, the Extremities of the nervous Papillæ, along its Sides; but especially towards its Tip, resembling the small Horns of young Snails, their Extremities being round, and bigger than their Bodies, and even pierce the external Membrane a little, to receive the Impressions, from the gustatory Particles of our Food. But that the Tongue might serve for more Uses than one, its Substance is made up of muscular Fibres of three Sorts. The first are Longitudinal; under them lie the transverse ones, which surround it, and then, those that run from its under to its upper Side; which, when they contract, make the Tongue long, thick, short, or broad, according to the Direction of their several Fibres. Besides which, it hath four Pair of Muscles to assist the former. The Use of the Tongue is manifold, as being the only Organ of Tasting; the Instrument of speaking, and of modifying the Voice; and also serves like a Rammer, to thrust our Food down the Oesophagus; besides, rowling it about the Mouth, and keeping it within bounds between the Teeth.

Of the  
Structure  
of the  
Ears.

Next to this are the *Ears*, the external Part of which, is a large cartilaginous Expansion, covered with a thin Skin, without Fat, and is full of Wrinklins and Windings, all serving for the Collection of the

Waves



Waves of the soniferous Air, to convey it into the Meatus Auditorius; for which end, there is situated a remarkable Protuberance, at the Entrance of the auditory Passage, called the Tragus, by which the Air is made to turn in, and not suffered to pass by this Passage, which it would have been apt to do without it. So that we may conceive of this outward Passage, or Appendix, as a Funnel to pour the Air into the Ear; and therefore, if it be cut off, the Hearing will be much impaired. From hence there goes a small long Hole or Passage to the inner Cavity, thereby augmenting the Force of the Sound; at the End of which is extended a Membrane, called the Drum of the Ear, fastened to one Leg of the little Bones, called the Hammer; behind which are several Vaults and anfractuous Cavities in the Os Petrosum, or Bone of the Ear, as the Fenestra Ovalis, Rotunda and Cochlea; the Vestibulum and Labarynth; all filled with internal Air, which receives Impressions from the External; so that the least Motion of it, is by this Contrivance, made perceptable by the auditory Nerves, that are here spread upon them. Their Nerves unite at their Origin in the Brain, which makes us discern no difference in Sound, though heard by both Ears.

The

*Of the NECK and BREASTS.*

The *Neck* is the Supporter of the Head, and suspends it at some distance from the Trunk of the Body, to give an Air and Stateliness to the Person ; and a quick Motion to the Head for its easier turning upon, and to elevate our Organs of Sense, as far as can be into the Air, for the forceable Reception of Impulses from Objects.

The  
Structure  
and Use  
of the  
Breasts.

The *Breasts* are another external Addition to the Body, and may be called an external Bowel ; for their Substance is purely Glandular, and of an oval Figure, lying and wrapped up, under the fat Membrane, each Gland sending forth an excretory Duct, which, in its Passage, unites with its Companions, and so compose larger and larger Ducts, which communicate with one another, lest any should chance to be obstructed, and incapable of carrying off its Portion of Fluid, till at the last approaching the Nipples, they unite together and form about seven or eight Pipes, which likewise communicate with one another, by cross Canals, that run between them. Through these seven Tubes, the Milk flowes, when the Breast is pressed upon by the Hand or Atmosphere, as in sucking.

Of what  
Use in  
Men.

In Women they serve to separate a chylous Liquor, for the Nourishment of the Child. The Nature of it, and Manner how separated, we reserve for another Occasion.

caſion. In *Men* they are but of ſmall Service, and ſerve, as ſome ſay, only for Ornament. But as Nature makes nothing in vain, and indeed, nothing for one ſingle Uſe, I think it proper to believe that they are of great Service; and are to be reckoned amongſt thoſe Parts, that had their Uſe before Birth; and, in my Opinion, are the Fountain of that Liquor the Fœtus ſwims in, and is nourished by in the Amnion Membrane that incloſes it; which is to me ſufficiently confirmed by Children having Milk found in their Breasts, as ſoon as born, and their aptitude to ſuck, which they had been formerly uſed to. And ſeveral Phyſical Authors give us an Account of Men having Milk in their Breasts; and a Couſin of mine hath affirmed often to me, that he ſaw a Servant-man of his Father's ſeveral Times preſs Milk out of his Breasts; which need not be thought impoſſible, if we rightly conſider the Mechanism of the Parts, and the plethorick Conſtitution of the Body; but this at the preſent we paſs by.

The Breasts are ſituated higher in Women than any other Creature for Beauty, and better Convenience in ſuckling the Child; and to be near the Heart, for the quick Circulation of the Blood through them, in order to have a great Quantity of Fluid ſecreted, and, as ſome ſay, from

Of their  
Situation.



a natural Modesty, that the Infant may not be used to those Parts too early, like Brutes that know nothing.

How  
Sucking is  
perform-  
ed.

To account for the Manner how Suction is performed by the Child, is almost needless, there being but few that can be ignorant of it, that know but any thing of the elastick Property of the Air, and its strong Pressure on the Surface of our Bodies. Now the Child performs sucking by putting his Lips around the Nipple, and then drawing back his Tongue, like the *Embolus* of an exhausting Spring, thereby making a Cavity between the Tip of his Tongue and that of the Nipple, void of Air, whereby the external Atmosphere exerts its Power in pressing the Milk, where the Resistance is taken off, and so constantly must flow out at the Nipple; and yet the Child can breathe all the while by the Nostrils, through those Passages behind the Uvula. But when the Child lets go that, the same Pressure of the Air acts upon that Part, by its Pressure, equally as on the rest of the Breast, two contrary and equal Forces destroying one another's Action, the Milk flows not out as before, till the same Alteration is effected again. The like Effect is seen in smoaking Tobacco.

The next Thing to be considered, is the external Parts of Generation, in the Male and Female; but all I shall say about them,

is,

is, That they are placed in the most retired Part of the Body, and near its Centre of Gravity, having many great Contrivances belonging to them, which out of my natural Modesty; and decent Respect to the Women, I desire to pass over. And as to Generation, and the Time and Manner of Conception, they more properly belong to the Book of Fluids. And as to the other Remarkables of the Body, that appear externally, they are most of them accidental, and result only from the peculiar Constitution of the Part; and those that would be farther informed of these things may consult other Authors.

## The CONCLUSION.

**N**OW to conclude, we have seen, that all the Parts of the Body, are but a Production or Continuation of the Heart and Arteries, consisting of an infinite Number of hollow Tubes or Vessels; and that there is no such Thing as a paranchymous Substance between the Extremities of the Arteries and Veins, but that all the Solids of the Body are Vascular, which Vessels are made up of Membranes, which Membranes are constituted of Fibres, and those Fibres are composed of solid Particles, purely and simply the most minute of all,  
ex-

extended partly as to Length, and partly as to Breadth, firmly cohering by the Laws of Attraction, and admitting no Cavity ; the first Elements consisting in the Stamen, and the rest secreted from the Humours, and opposed between the Particles of the other by Nutrition.

And out of these Fibres, Membranes and Vessels, are framed, all the Bowels, with the Bones, Cartilages, Ligaments, Nerves, Muscles, and Skin ; so that by the various Textures and different Combinations of some of the Fibres, all and each Part of the Body is formed ; as the Heart, Brain, Stomach, Lungs, Liver, Legs, and the rest of them, the Sum of which makes up the whole Animal Structure ; and all the Parts differ from each other, only by the greater or lesser Composition, or Addition of the most minute Solids or terrestrial Matter, that they are made of, and nourished by. So that, in short, as was said before, the whole Body is Vascular, the first and largest Vessel being the Aorta, and the last and smallest the excretory Ducts of the Glands, and which are all constituted of Fibres, that had their first Original in the Stamen, and increase or expand by Nutrition or the Addition of fluid Atoms, after Conception.

And to examine into the Nature of Fibres, which are the very Basis, or fundamental  
Prin-



Principles of the Animal Body, they have all an elastick Property, whereby, when separated, they contract themselves up, much shorter than before, and which proceeds from a particular Configuration of the constituent Particles of those Fibres, and the Juices they contain within the most minute Vessels which they constitute; together with their particular Situation, or Position towards one another, leaving small Spaces or Vacuities between their most minute essential Particles, which are again covered by those Atoms that lie next to them; thus making so many *Vacuums* in a Fibre, whereby they can yield to a certain Length, till such Times as those superincumbent Particles collapse, with the Extremities of the other directly under them, and so fill up those Spaces, which their former Arraignment had formed, whereby they become all equal in a direct Line, and so lose their Elasticity. This elastick Property of the Fibres is exceeding needful; and when, or where-ever it is weak or wanting, occasions various Distempers of that Part, and which will admit of no lasting Cure, till the Fibres are corrugated again, and made elastick as before; as we see is the Case of Intermitting Fevers, the Fluor Albus, loss of Appetite, and the like.

Now all these Fibres, of which the whole Animal is constituted, have a vast

A a

Dif-

Difference from one another, though all essentially of the same Matter; I mean, those Parcels that come under a particular Denomination, and seem, at the first Sight, to be of a distinct Species, to wit, fleshy, nervous, and osseous Fibres; for, I think, those comprehend all of them, and make up their compound Parts; though, in reality, they differ only by reason of the Multitude, or Number and Closeness of the Atoms of Matter, of which they are made, together with the more close Apposition of the particular Fibres of those compound Organs; As for Example, the bony Fibres are stowed the most close; and all the Particles constituting each Fibre thereof, are exceeding small, dense, and closely cohering; wherefore they are both more solid, and of a whiter Colour than any other belonging to the Body, and very brittle, with other like Qualities, that are peculiar to such Substances, and depend on such Causes. Fleshy Fibres have larger Spaces between each Fibre, and each Particle of each single one; and those Particles are larger than the former; and therefore are soft and tenacious, and by admitting many Rays of Light, and reflecting but few, and transmitting many, occasions their transparency and horny Colour. The nervous Fibres are a Medium betwixt the two former, which makes them partake of the Pro-

Properties of both: And thus, by tracing the Minutia of Anatomy, I think, a clearer Notion and Knowledge of it may be obtained, than only by reading the disputing Part of it. And this Account, if not exact in every Particular, yet there is much Truth in it: For what is the Bone, that is so commonly found in the Stag's Heart, and in some old Men's too, but some of the fleshy Fibres of its Columns ossified? And a further Proof of this is the Orifice of the Aorta, that hath also been often found ossified in People of Years; and from the same Cause with the former. Besides, were not the Bones themselves at the first Membranes, and so continued, till their Interstices were filled up with nutritious Particles, and, by their close Colusion, gave the following Properties to them? Here some may ask, Why are not the Nerves ossified then, or much hardened? Much hardened they oftentimes are, but as to being often, or at any time ossified, the Reasons may be because of the balsamick Juice that flows in them, and that they are not exposed to the great Heat as the other; I mean any remarkable Branch of them; not but that some small Branches of them (as these are no Part of the Body without them) but may be ossified, along with the fleshy ones, being forced to it by the circumjacent Pressure of the former, which stop the Current



rent of their Juice, and so converts them into a dry, hard, white, brittle Substance along with themselves.

And thus finally we see, that all the compound Organs of this noble Body of ours, are, by the various Texture and Combinations of more or fewer of the aforesaid three Kinds of Fibres, the Osseous, Carnous, and Nervous, wonderfully framed; which, by examining further, may be reduced into their first Principle, *viz.* Matter. And so out of one common Matter, the Body in general is constituted; and from the particular Figure, Magnitudes and Densities, and Positions of those Particles, all the Particulars thereof arise: As first, fleshy, bony, and nervous Fibres; from those the Bones, Cartilages, Ligaments, Membranes, Arteries, Veins, and Nerves: And from a Combination of these again, the Extremities, the Skin, Testicles, Intestines, Spleen, Liver, Lungs, Nerves, Stomach and Heart; from which we first set out, and have now returned to again; where it follows to speak of its Fluids; but of those enough for this Part.



